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AIR-PAK HYDROVAC

Either Way –YOU'RE ON THE ROAD TO BETTER POWER BRAKING!

There's no need to be puzzled about the question of efficient power braking for *any commercial vehicle.* Where the preference is for a hydraulic system, Hydrovac, with over two and a half million installations, has proven itself the undisputed leader in its field. And for vehicles where air actuated brakes are the choice, the new Bendix Air-Pak air-hydraulic power braking unit is foremost in its field.

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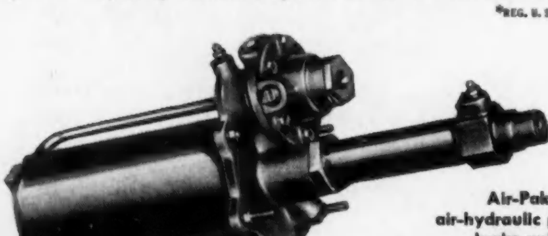
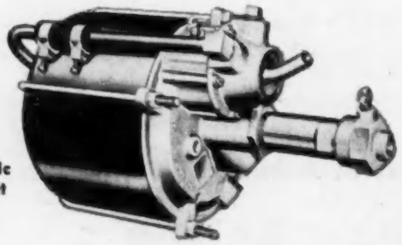


Air-Pak air-hydraulic power brake unit



Hydrovac vacuum-hydraulic power brake unit

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SAE Means:

Success At Engineering

SAE is great, it seems to me, because it does well what it sets out to do—and sets out to do just what its Founders suggested.

Our original Constitution said we were "to promote the Arts and Sciences connected with Automobiles and Automobile Construction, by means of meetings for social intercourse and the reading and discussion of professional papers . . . and to circulate, by means of publications among its members, the information thus obtained."

Every time a Constitution Committee, a Council, or an SAE membership looked over our setup to modernize it, they came up with the same conclusion about what we ought to be aiming at. They changed "Automobile" with a capital letter to "automotive" with a small one, and added a phrase to include users as well as "constructors," but the basic meaning wasn't changed. Our 1951 marching orders tell us:

"To promote the Arts and Sciences and Standards and Engineering Practices connected with the design, construction, and utilization of automotive apparatus. . ."

Four or five major overhauls of the SAE Constitution, in other words, haven't changed basically this definition of objective. . . And I can see why.

That fixed objective, I believe, has played a big part in SAE's growth to greatness. It has made possible many things. Among them:

1. Concentration of member time and effort in areas of unquestioned mutual interest. SAE has been able to come through with what it claimed to offer in useful, pertinent exchange of ideas.

2. Almost complete absence of non-essential disagreements. Coming together as automotive engineers to discuss engineering, its members have provided themselves a climate in which only engineering exchanges thrive. Differences of politics, economics, religion, personal ambitions don't get in the way.

3. Building of cumulative, related paths of knowledge and cooperative action by its 46-year parade of members. Using a common road map, each SAE generation has improved the highway to a permanent, common goal. SAE hasn't chanced bogging down in detours.

4. Prevented dissipation of available member time over too wide areas of activity. SAE's strength lies in doing well its appointed job; leaving related interests to others.

These are among the major conclusions I have reached from studying SAE history, policies, and programs. I've been enthusiastic about SAE ever since I joined it back in 1928. But when I became president a few months ago, I started to analyze that enthusiasm. As president, I knew I would be talking much of SAE in the forthcoming year. I wanted to be able to explain some of the whys of my esteem for the organization—not just record its existence.

by Dale Roeder

President of SAE for 1951

So, I tried to look behind the scenes; I sought a basic cause for our idea-packed meetings, our outstanding publications, and our vast technical committee service to industry and government. And the more I looked, the more I became convinced that SAE's Constitutional singleness of purpose has as much to do with our success as any other single factor.

That's why I wanted our 1951 Council to reaffirm the single-purposed interpretation of our Constitutional provision about SAE's objective—as other Councils had done before it.

So, I asked the Executive Committee to review again the possibilities for other than strictly engineering activities which have appeared from time to time. Political stands on local or national issues were discussed and discarded—even though the issues might involve a need for engineering knowledge. Participation by SAE Sections in local organizations likely to be involved in political, economic, or commercial questions was also scanned.

The result was a resolution, unanimously approved at the April Council meeting, which—following the usual whereas's—concluded:

"The SAE Council reaffirms previous interpretations of Section C2 as limiting Society activities to the technical and scientific areas of automotive engineering and that it therefore is not empowered to authorize direct or indirect participation by the Society or any of its agencies in activities which lie outside these areas."

I believe the Council's action is another firm stride toward the common goal of SAE members.

Where We Stand on

Nonferrous Materials

EXCERPTS FROM PAPER BY

Dr. Richard J. Lund, Supervisor, Engineering Economics Division, Battelle Memorial Institute

• Paper "Where Do We Stand on Nonferrous Strategic Materials?" was presented at the SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1951. Manuscript completed Feb. 9; developments after then not included.

OUTLOOK for major expansion in future supplies of nonferrous metals is not encouraging, except for aluminum and magnesium. For copper, lead, and zinc we're dependent on new major ore discoveries, either domestic or foreign. For the light metals, it's a case of developing additional supplies of cheap power, with mine output no serious problem for the present in the case of aluminum, and never a problem for magnesium.

For the immediate future, domestic price controls and tariffs will raise hob with our imports. Plans recently announced for setting up an international program for stimulating production and allocating supplies will take plenty of time to effectuate—it's an exceedingly complex matter. Eventually, this may do some good. But it's really wishful thinking to believe that the extraordinary demands for metals such as we've been recently experiencing—for guns, plus butter, plus hoarding, plus panic buying, plus speculation, plus government stockpiling—could ever be met. And frankly, it would be senseless to try to meet them in full.

We'd undoubtedly be in much better shape so far as domestic output of critical and strategic metals is concerned if our fiscal climate in the past decade or more had been more conducive to capital risks in the long-shot game of mineral exploration and development. A 1950 canvas of companies represented in the Mining & Metallurgical Society of America indicated a *decline* in domestic exploration and development for strategic metals of 96%; for precious metals of 90%; for copper, lead, and zinc of 57%; and an average for all nonferrous metals of 74%. These are percentage *declines*, 1950 compared with 1940.

Official state figures on numbers of underground lode operations in a few of the western states are even more shocking. Between 1940 and 1950 these operations declined as follows: 95% in Oregon, 76% in California, 63% in Nevada, and 89% in Utah. These startling figures prove conclusively that something is haywire.

Mining men are in full agreement that the situation stems from the unfavorable environment that for many years has prevailed in government regulations relating to taxation, tariffs, and mine financing. Our government leaders and legislators could well take a leaf from Canada, which recognizes the special and unique problems of mining through much more liberal fiscal policies. Unless this is corrected in the United States, our minerals are bound to become more and more scarce and costly, with greater and greater dependence on distant and insecure foreign resources.

Following are highlights of the supply-demand picture, stockpiling, controls, foreign developments, and future prospects for copper, lead, zinc, aluminum, tin, cobalt, cadmium, and diamonds.

Copper

Consumption in 1950 was just short of 1½ million tons. Of this, about two-thirds came from domestic mines, and the remainder from scrap and from imported ore, concentrates, and refined metal. Government stockpiling and exports took additional large tonnages.

In order to meet these record demands, stocks were drawn on heavily—total stocks of refined copper held by producers, custom smelters, consumers, and nonconsumers dropped about 133,000 tons. Producers' stocks of refined metal were down to 49,000 tons at the end of the year—less than a two weeks' supply.

Projecting recent mine production figures over

Continued on Page 21

Strategic Materials

Ferrous Metals

BASED ON PAPER BY

E. C. Smith, Chief Metallurgist, Republic Steel Corp.

• Paper "Status of Ferrous Strategic Materials—Government and Industry Situation and Rulings" was presented at the SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1951.

THIS country's demand for steel is likely to reach 100 million net tons of ingots in 1951. We can get the ore to meet the demand. But we will probably have to step up our mine-to-smelter transportation system and face shortages of coal, scrap, and alloying elements.

To produce 100 million net tons of steel ingots will require 103.4 million gross tons of ore. These sources might furnish it shipped:

	Millions of gross tons
Lake Ore	81.4
Southeastern States	8.0
Western States	5.0
Northeastern States	4.0
Chile	2.5
Sweden	1.0
Venezuela	0.5
Miscellaneous	1.0

The ore is available—as long as we can get it. Foreign ores subject to open ocean shipping constitute only 5% of the foregoing total. But whether domestic sources could make up the deficit if this 5% were cut off is questionable. One reason is that for years this country's long-range tax policy has severely limited development of our ore mines. We lack entrance to the ore and transportation facilities from working area to point of assembly for shipment.

No new domestic or foreign source, even up to 1% of our need, is in sight for 1951. Venezuela probably won't cross the million tons per year mark before 1953. The new Labrador and South American ores are further into the future.

Moving the Lake ore to the smelters will require rail as well as ship transportation. At the close of navigation in 1950, ships had carried 78 million gross tons of ore on the Lakes. The railroads moved probably more than 2 million gross tons from the Upper Lakes by the end of 1950. Rail shipments will continue until navigation begins again in May. If annual demand rose above 100 million net tons of ingot steel, surely the 48-hr weekend tie-up of most transportation facilities would have to end.

The amount of coal that will be available for steel production is up to the head of the miners' union. In 1948, the year when steelmakers turned out about 90 million ingot tons, 107.6 million tons of coal yielded 74.9 million net tons of coke. Of this, about 60 million net tons went into the making of iron and ferroalloy. The foundry industry used about another 4 million tons.

Defense demands dislocate the whole pattern of scrap. While industry shuts down to convert from peacetime production to defense orders, it produces little scrap. Even when war production begins, scrap does not appear immediately, as production cycles are long. For example, after the ingot for a tank gun is cast, it takes about one whole year before rifling of the bore and final inspection reveal whether the product is a weapon or scrap. The very highly alloyed steels find end use in products taking the longest time to fabricate. Wartime scrap lag is about three times the peacetime lag.

When scrap does begin to flow back to the steel melting furnaces, it presents a new problem: how to salvage the precious alloying elements. During one period in World War II, the Central district of Republic was deriving 15% of the weight of its alloy-steel ingots from alloy turnings. Even so, the plant was not using up all the scrap generated by its alloy users.

Alloy-bearing scrap can be saved by electric-furnace melting. But power requirements limit its use. Scrap remains a problem as long as war continues.

No one knows yet what alloy steels and how much

Table 1—Consumption of Alloying Elements

	1948 Consumption, lb	1949 Consumption, lb
Chromium	212,708,570	148,442,803
Cobalt	916,953	991,645
Columbium	796,495	632,051
Molybdenum	16,348,818	11,243,780
Nickel	76,763,848	51,882,941
Titanium	3,784,965	4,222,221
Tungsten	4,313,518	2,170,483
Vanadium	1,550,147	1,079,024
Zirconium	2,069,335	1,440,141

Table 2—Consumption of Copper, Lead, Tin and Zinc

	1948 Consumption, net tons	1949 Consumption, net tons
Copper	66,588	63,030
Lead	22,518	19,242
Tin	38,363	35,950
Zinc	252,588	267,019

Table 3—Consumption of Ferroalloys

	1948 Consumption, net tons
Ferromanganese	647,617
Spiegeleisen	112,610
Ferrosilicon	814,297
Ferrophosphorus	32,297
Ferrotungsten	2,324
Other ferroalloys	282,376

of them the industry will be called upon to produce. Whatever the alloy demands are, they will be difficult to meet.

In 1945, when the jet-engine program reached the alloy-steel division of the World War II equivalent of the present NPA, it was found that high-temperature parts would require substantially all the available nickel and low-carbon ferro-chromium as well as more than the visible supply of columbium, cobalt, and tungsten. Future aircraft programs may be just as bad or worse.

Tables 1, 2, and 3 show some recent figures on consumption of alloying elements and other metals used in steel production. Here are predictions of what we can expect to have in the future:

Manganese

In case of all-out war, we may have to fly in our manganese from Africa. Russia has been the big producer of this element. The African Gold Coast, the Union of South Africa, India, and Brazil are now major suppliers of the United States.

Imports into this country for consumption totalled 610,000 tons of contained manganese during the first eight months of 1950. This indicates that some 2 million tons of manganese ore entered in 1950. Wartime needs could be expected to be much higher.

Columbium

This element, used to stabilize chromium-nickel stainless steels and as a component of super alloy metals, will probably be the scarcest. Total production is barely 1,200,000 lb per year. Nigeria, the single important source, uses small placer mines not amenable to modern dredging or mechanized mining.

Vanadium

Although war doubles peacetime demands for vanadium, it should be more plentiful than other alloying elements. However, U. S. vanadium-ore production figures are not made public because this ore is usually associated with uranium ore here.

Peru, Southwest Africa, and Northern Rhodesia also produce important quantities of vanadium ores.

Molybdenum

Consumption is decreasing. The steel industry used less than 12,000,000 lb in 1949. Any major war program would reverse the trend.

In recent years, more molybdenum has come from molybdenite from the porphyry copper mining operations than from the molybdenum mines at Climax, Colorado.

Titanium

There should be ample titanium for stainless steel. Ferrotitanium supply for the industry will not be affected by the current developments to produce metallic titanium.

Tungsten

In peacetime, the United States consumes half the world's annual production. Now that the Korean war has shut off China, our primary source of tungsten, the rest of the world production will hardly meet our needs.

Chromium

U. S. consumption in 1948 of chromite, the ore from which chromium comes, was 875,033 tons. U. S. production was 3619 tons. Most of the difference came from Cuba, the Philippines, Turkey, Southern Rhodesia, the Union of South Africa, and New Caledonia. Heat-resisting metals require chromium. No new deposits of metallurgical chromite have been reported.

Nickel

Production of nickel is limited now partly because neither industry nor government wanted the production capacity available in 1949. Production cannot be increased by International Nickel's new mines at Sudbury, Ontario, for some time, as it will take years to complete work on the headings, drifts, and raises which must honeycomb the ore body

there. Besides, construction of loading stations, haulage ways, and underground repair and service stations must precede operation.

Cobalt

Judging from experience with production plans in 1945, steel men can expect high-temperature metals for aircraft gas turbines to require the total visible supply of cobalt if war comes. There will be demand, too, for cobalt for permanent magnets in electronic equipment.

The United States consumed 5,049,597 lb of cobalt during 1948, with the metal industry accounting for 3,318,428 lb. Only 916,953 lb was used in alloy steels.

Of the 13,680,000 lb of cobalt produced in 1948, 9,510,000 lb came from the Belgian Congo, 1,547,000 from Canada, 613,000 from French Morocco, and 809,000 lb from Northern Rhodesia.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Nonferrous Materials—continued

the full year 1951, will give an output of between 950,000 and 1,000,000 tons—less than 10% ahead of 1950. Scrap intake by producers is expected to be less this year than last, and stocks are down to an irreducible minimum. Imports may very well be less this year than last, with our tariff and price controls tending to channel more of the foreign metal to more profitable foreign markets.

Government restrictions on use, incorporated in Order M-11, M-12, and Amendment 1 to M-12, will cut demand sharply this year. The 15% cutback in January and February rose to 20% in March. Prohibition of copper usage in a long list of products was also effective on March 1st.

Relaxation of the government stockpiling program announced late in February should offer some relief to the stringent supply situation.

Major problem of the long-term future is mine production, since smelter and refinery capacity here and abroad are ahead of mine capacity. There are only three or four major hopes on the horizon domestically: (1) the San Manuel development in Arizona, which may add from 75,000 to 80,000 tons annually by 1954; (2) the White Pine operation in Michigan that could add a similar amount at about the same time; (3) the Greater Butte project that in the long run will merely balance off depletion of present Butte operations and prolong the life of the whole district; and (4) the Bisbee East project in Arizona, with no current estimate on output. Altogether these may add as much as 15 to 20% to domestic output, but not until 1954 or even later. On the other hand, the net increase may prove less than this, due to depletion of presently producing mines.

In the foreign picture, development of the sulfide ores of Chuquicamata in Chile will add around 250,000 tons yearly by 1952, but these, again, will largely serve to supplant shrinking future production from oxide ores that have been the source of copper in the past.

In Africa, the comparatively high grade ores of Rhodesia could provide substantial future output boosts, but power and fuel shortages are serious obstacles to any rapid expansion.

All in all, copper's future is not nearly so rosy as that of steel and aluminum, so far as assured increases in supplies are concerned.

Cadmium

Cadmium supplies are tied directly to zinc, about 10 lb are produced per ton of slab zinc by zinc smelters and refiners from domestic and foreign ores. It's recovered from flue dusts and sludges, and all zinc producers are now equipped with efficient recovery facilities. In spite of record output of probably 4,500 tons in 1950, supplies were short of record demand, and stocks were undoubtedly reduced substantially. Late in December the NPA issued Order M-19 which specifically prohibits use of cadmium for any purpose or for any product not listed in the order, and limits inventories to a 30-day supply.

Lead

With lead consumption at a record level of about 1¼ million tons in 1950, demand was still not fully satisfied. Domestic mine production supplied about a third of the needs, scrap a little less, and imports about 40%. Imports, incidentally, were the largest in the history of the industry, and were especially heavy late in the year in order to beat the rise in the tariff effective Jan. 1. Stockpiling probably took close to 100,000 tons before the program was shelved on June 30. Producers' stocks of primary lead were cut in half during the year, from 70,000 tons to 36,000 tons, the latter representing just 1½ weeks' supply.

Supplies this year will almost surely fall below last year's figure. Somewhat higher mine production will be offset by a serious drop in imports. A sizable amount of the record 1950 receipts of foreign lead represented liquidation of stocks abroad accumulated during the weak markets of 1949. This metal is now gone. Furthermore, European demand for the metal will be much higher in 1951 than in 1950. And with our import duty doubled as a result of the cancellation of the Mexican trade agreement, foreign metal is bound to seek more lucrative foreign markets.

Other than general regulations which prohibit hoarding of the metal and concentrates, the only order on lead, M-38, was issued in February, and merely limits inventories to a 60-day supply. As

a result, it may be expected that lead will be used wherever possible as a substitute for metals having severe use restrictions. Such possible substitutions are quite limited, however.

Prospects for increased supplies, both domestic and worldwide, are slim. Domestically, the western copper developments in Arizona and Montana will add some byproduct lead, but relatively minor amounts. Plans recently announced by St. Joseph Lead Co. for an expansion program at their operations in Southeast Missouri will probably constitute only a small increase in total domestic supplies. By and large, our lead resources are in a stage of late maturity, with every indication that we'll be increasingly dependent on foreign supplies in the future.

Abroad, there are developments in Argentina, French Morocco, and Tanganyika that may add 5 to 10% to world supplies in two or three years. Rehabilitation of the war-damaged Burmese mines, a major world producer in pre-World War II days, is progressing at a disappointingly slow pace.

Zinc

Like the other nonferrous metals, the zinc picture is one of record or near-record production and consumption in 1950, with producers' and consumers' stocks seriously depleted. But demand was and is still unsatisfied.

Consumption in 1950 was a record-breaking 950,000 tons—7% over the previous record in wartime 1944. In addition, government stockpiling took an estimated 125,000 to 150,000 tons. About 910,000 tons of slab zinc were produced, smelters' stocks were drawn down by about 85,000 tons, and about 155,000 tons were imported, making total deliveries a record 1,150,000 tons. At the end of 1950, smelters stocks were below 9,000 tons—less than four days' supply. Consumers' stocks were also reduced substantially during the year. At the end of October they represented only about a 3-weeks' supply—only about half the amount permitted by government regulations.

Production from domestic mines of 617,000 tons was well below the wartime peak of 768,000 tons in 1942. Imports of ore accounted for an estimated 270,000 tons, mainly from Mexico and Canada.

It's possible that domestic mine output may be increased this year by around 10%. Smelter output may thus rise to between 925,000–950,000 tons. Scrap shortages will tend to hold down smelter output to this range.

The major change in the past decade in domestic mine output has occurred in the Tri-State district. From its peak output of about 260,000 tons in 1941, production dropped steadily to a low of 79,000 tons in 1949, and rose only slightly to about 82,000 tons in 1950. Thus, the leading zinc producing district in the United States is now producing less than a third as much zinc as it did 10 years ago. This results from fewer mines producing from lower grade ores, and from a virtual stoppage of retreatment of old tailings in the district, which accounted for much of the output in the past. Although high prices will bring out some increase in output, it's doubtful if this district even under an all-out effort will or can duplicate its output of World War II.

Other than byproduct output from new copper projects in the West, there are no major new developments in zinc that can boost domestic supplies substantially in the future. Increased output will come largely by opening up many small marginal operations or expanding output from present producers.

Official stockpile figures are secret, but trade members guess it amounts to from 500,000 to 600,000 tons—the largest of any major nonferrous metal. A moratorium on the stockpiling program declared early this year will provide some relief.

Various forms of zinc, zinc alloys, zinc scrap. and zinc ores are included under government inventory controls, NPA Regulation 1. NPA Order M-9 provides limits to which zinc producers must accept DO orders, and calls for a 30-day lead time. NPA Order M-15, effective December 1, 1950, restricts the civilian use of zinc metal and zinc metal products during 1951 to an average quarterly rate of 80% of the use during the first six months of 1950. Inventories were set at 45 days or a practical working minimum, whichever was less. Use of zinc to substitute for cadmium in electroplating is exempted, and maintenance and repair use at 100% of the base period is permitted.

In the foreign field, the only sizable new mine production that can be hoped for is some 60,000 tons annually to be available from French Morocco starting in 1953. Canada may boost her output this year by some 10% (15,000–20,000 tons). Minor increases may be realized from other foreign countries. Smelter and refinery capacity will be substantially increased by Cerro de Pasco at their Peruvian operations, but it's not clear how far mine output will be boosted. Nothing in the way of a really major new development is on the horizon.

Hence, it appears inevitable that zinc will be in short supply for some time, assuming moderate and steady increases in world demand. It's quite probable, however, that the moratorium on stockpiling plus the civilian-use cutback will soon permit replenishment of inventories to permissible limits and result in a reasonably balanced supply for the nearby future.

Cobalt

Cobalt was headlined late last year when Order M-10 Amended subjected the metal to complete allocation as of February 1, 1951, with the probability that uses having low essentiality such as radios and TV sets and many household appliances will suffer severely.

We're using about 2500 tons annually, but this will undoubtedly mushroom with expansion of our jet engine output. Its principal war use is in so-called superalloys for severe service at high temperatures in turbine blades, buckets, and discs.

In the past we've been almost totally dependent on foreign sources for our supplies. Most come as a byproduct of copper operations in the Belgian Congo. Rhodesian output has been earmarked for Great Britain. We may get some of the Rhodesian ore in the future, together with metal from planned operations in Uganda and boosted French Morocco supplies. Both International Nickel and Falconbridge are now recovering substantial amounts from

their nickel operations, and the Lynn Lake development will produce cobalt. In addition, the old Cobalt district is making another comeback. Altogether, these foreign sources may supply us with some 5000 tons of metal equivalent by next year, and more later.

Here at home, a new development in Idaho should yield about 1500 tons per year by 1952. Potential output from Missouri and tailings from Pennsylvania may give us another 500 tons.

So total supplies by 1952 or 1953 may reach 7000 tons—almost three times our recent consumption rate. But stepped-up defense uses plus essential civilian uses and government stockpiling will undoubtedly take all of this, leaving little available for applications having low essentiality.

Aluminum

Turning to aluminum, we find the same tight current position, with severe government use limitations and prohibitions. On the other hand, the longer term outlook appears much more favorable than for any of the other nonferrous metals.

With a 1950 record peacetime output of 714,000 tons of primary metal, suppliers were still for short of satisfying demand. Secondary output, imports, and reduction of producers' stocks raised total supplies to an estimated 1,170,000 tons, an increase of some 300,000 tons over total 1949 supplies.

It's my guess that primary output in the first quarter of this year will be at an annual rate of close to 780,000 tons. With the reactivation of equipment sold last summer by the government from its remaining standby facilities, plus output from reactivated high-cost private standby facilities, primary production this year may well reach about 800,000 tons. With curtailed aluminum consumption, by edict, and increased government stockpiling, secondary output from scrap may well fall to around 200,000 tons. Imports, however, will probably top last year's figure and comprise another 200,000 tons. Thus total supplies may well reach about 1,200,000 tons in 1951, of which probably from 150,000 to 300,000 tons will go into the government stockpile, depending on how rapidly aircraft and other military requirements develop.

As for 1952 and 1953, present plans call for additional capacity boosts from three large new plants to be built, one by each of the present primary producers. There'll be output from two other small plants to be built by newcomers in the primary metal field, Apex Smelting Company and Harvey Machine Company. Probably by mid-1953 we'll have an *economic* capacity to produce about 1,090,000 tons of primary metal plus high-cost capacity of around 80,000 tons—a total well ahead of the peak World War II capacity of 1,132,000 tons. Much of that involved use of high-cost power that was uneconomic in normal times. There's been serious talk, of course, of boosting our primary output to a figure of some 1,700,000 tons. There may well be considerable doubt whether sufficient low-cost, *unsubsidized* power exists in the United States, even presently undeveloped, to produce this much additional metal prices comparable with those now prevailing for primary metal.

On the other hand, tremendous reserves of low-cost hydro power exist in Canada. Recent reports say the Aluminum Company of Canada is now ready to start on a new $500 million project in British Columbia that will supply some 550,000 tons of metal in from three to five years.

These U. S. and Canadian plans call for virtually doubling the North American primary aluminum capacity in the next three to five years. Western Hemisphere bauxite resources are ample to support such a growth expansion, although ore of somewhat lower grade may have to be tapped. Early this year Alcoa announced plans to build a new alumina plant in Arkansas to increase their capacity by 50%, equivalent roughly to 500,000 tons. They are also doubling the capacity of their E. St. Louis alumina plant.

Aside from early NPA regulations on inventories and providing preferential rating for DO orders, aluminum has been subjected to the following orders:

Order M-5 set ceilings on DO orders that must be accepted ranging for various products from 15 to 40% of average monthly shipments in the first eight months of 1950. Amendment 1 to this order, issued February 5, raised the top limit to 45%.

Order M-22 provides for the orderly flow of alubeginning January, 1951, to 80% of the average monthly in the first six months of 1950. This was reduced to 75% in February, and to 65% in March and thereafter. Amendment 2 to this order is similar to the copper Order M-12, Amendment 1, in prohibiting after April 1, 1951, the use of aluminum in more than 200 products of low essentiality in the defense program.

Order M-22 provides for the orderly flow of aluminum scrap to aluminum producers and certain approved smelters and fabricators, and requires special NPA approval of conversion deals in aluminum scrap.

Tin

Skyrocketing tin prices since the Korean war have reflected the terrific scramble to obtain tin from southeastern Asia, the world's major tin source, while the getting's good. But actual consumption in the United States in the late months of 1950 is estimated to have jumped to an annual rate of 90,000 long tons from the pre-Korean rate of around 70,000 tons—about the same as 1949. Added pressure for increasing the government stockpile take has contributed to the unsettled situation. And speculation has undoubtedly added its sizable share. About two-thirds of our consumption comes from primary metal, and one-third from secondary.

We're totally dependent, of course, on foreign sources for our tin, either as metal or ore. We're producing about 35,000 tons annually from our Texas smelter (its maximum output was 43,500 tons in 1946), but are dependent on Bolivia and Indonesia for ore to feed it.

World tin production has been in excess of consumption for several years. Were it not for stockpiling, hoarding, and speculation, current output (about 173,000 tons in 1950) would be more than adequate to meet anticipated consumption. World stocks of tin, including that afloat and in ore and concentrates, amounted to 228,000 long tons at the

end of July, 1950, of which U. S. stocks were 176,000 tons, including an estimated 110,000 tons in the government stockpile.

Development of electrolytic tin plating and solders with greatly reduced tin content during the past decade has spread our tin intake a lot thinner than with the old hot-dip process. The coating is only one-half to two-thirds as heavy, and tin content of can solders has been reduced from 40% to 8%. Percentage of tinplate produced electrolytically in the U. S. has jumped from 3% in 1942 to 57% in 1949. Five new electrolytic lines will be added this year and next, boosting this percentage a lot higher.

Controlwise, a flood of orders and regulations was issued late in January. Order M-8 Amended was a comprehensive regulation enumerating permissive uses of tin; limiting quantities so used in comparison with the base period to 100% in January and 80% in February and March; limiting inventories; providing for signed certifications; and requiring the filing of reports. Probably of main interest to automobile builders is the permission to use 20% tin solder for a filler or smoother for automobile bodies or fenders, 21% tin solder for cellular-type radiators, and 30% solder for fin- and tube-type radiators. Order M-24 deals with tin plate and terneplate. M-25 is a metal-can specification and limitation order. M-26 is a tin-plate closure order. M-27 deals with collapsible tubes.

Magnesium

Magnesium, too, was in short supply for the last half of 1950 and remains thus. Voluntary allocations were invoked by industry in mid-year and still continue, in order to assure a reasonably equitable distribution of metal for civilian use. Government orders concerning inventories and hoarding have supplemented allocation action by private industry.

Output of primary metal in 1950, estimated at 16,000 tons, was about 35% ahead of 1949. But production at the only producing plant—Dow's electrolytic plant at Freeport, Texas—was pushed up gradually during the last half of the year, so that output now is at the plant's full capacity rate of 24,000 tons per year. Secondary metal produced from scrap in 1950 amounted to about 6,000 tons. Stocks of primary metal were reduced by almost 5,000 tons. Thus, total consumption in 1950 was around 27,000 tons. This was about 50% above total consumption in 1949, and reflects the growing popularity of the metal for civilian uses as well as for military applications.

In mid-September last year, the government announced its intention to reactivate six of the plants still held in standby located at Painesville, Ohio; Velasco, Texas; Canaan, Connecticut; Manteca, California; Wingdale, New York; and Spokane, Washington. Together they have a capacity to produce 98,000 tons of primary metal—54,000 tons by the electrolytic process at the first two plants, and the remaining 44,000 tons by the ferrosilicon process. Plans were announced in January for the reopening of five of the six plants: the Canaan and Wingdale plants in mid-February, Painesville in April, Velasco in May, and Manteca in July.

Due to various factors, magnesium from most of these operations will cost more than the metal from the Dow Freeport plant, now the sole commercial producer. So the government will pay for the output on some sort of cost-plus basis and stockpile it.

With the reactivation of all six government plants at full capacity, and capacity operation at Freeport, primary magnesium output will be at the rate of 122,000 tons annually—about five times present output, but still far short of the record 184,000 tons attained in 1943 from plants having a rated capacity of 293,000 tons.

Magnesium is presently used in manufacturing titanium metal. If, as appears assured, titanium output mushrooms as a result of war requirements, substantial amounts of magnesium will be needed in its production.

Ore supplies are no problem in magnesium's future, since it is produced most cheaply from sea water. Power, however, is a potential bottleneck. In the electrolytic process, about the same amount is needed per pound as for aluminum, about 9 kwhr. Less than half as much electricity is needed in the Pidgeon process, virtually all of which is consumed in making the ferrosilicon used in the process.

Of great significance to the future of the magnesium industry is the plan announced by Dow in 1950 to construct a continuous rolling mill for magnesium at Madison, Illinois. Located near St. Louis, the recently acquired plant buildings will be altered and equipped as soon as possible. Plans call for completion of the plant in 1952. With an ultimate capacity of 3 million pounds of sheet monthly (compared with total present rolling capacity of about 400,000 pounds monthly), this facility should go far in lowering substantially the spread between prices of ingot and sheet magnesium and in boosting the growth rate of this industry.

The present mobilization program will put magnesium firmly on the map as a structural material for widespread uses and assure its future popularity as a tonnage metal for civilian purposes.

Diamonds

The automotive industry may well be the number-one user of industrial diamonds for cutting and abrasive wheels, cutting tools, and for truing abrasive wheels.

Supplies of crushing bort are very tight. Shipments in 1950 are estimated at around 4 million carats, with the recent rate far below this figure. In fact, one large supplier recently advised that consumption in normal channels is almost three times what they're now getting from abroad. So there's been some talk of tapping government stockpiles. But this is undoubtedly wishful thinking at this stage of the emergency.

The supply-demand situation in toolstones and drilling material is reasonably well balanced, but with no reserves of the latter.

Important developments under way in French Equatorial Africa may result in a substantial addition to world diamond production and reserves in a few years.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

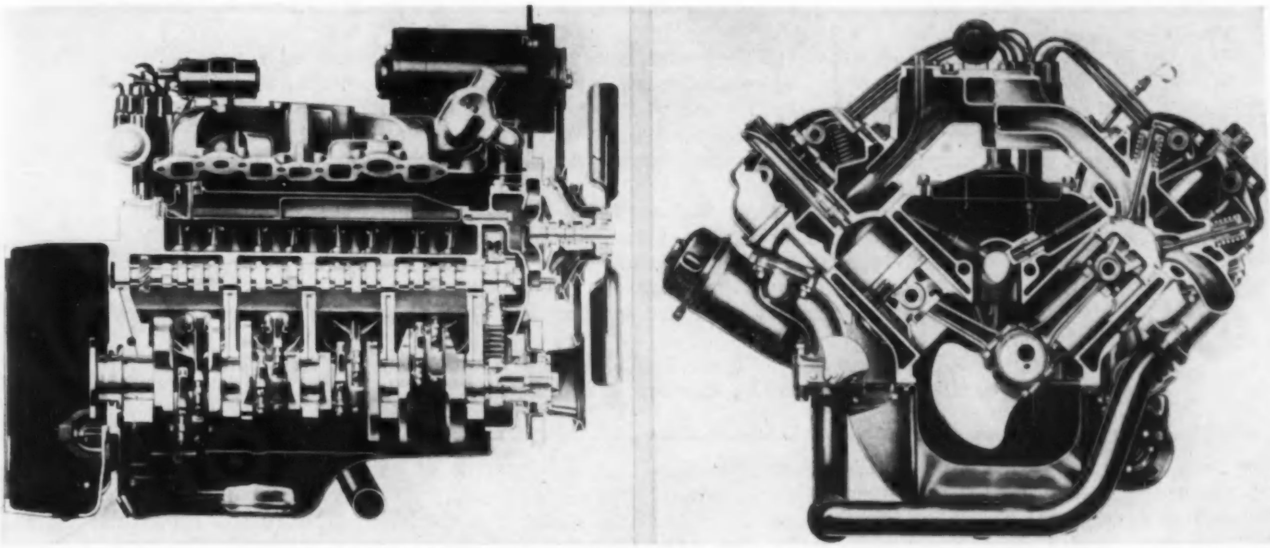

Fig. 1—New Chrysler V-8 engine.

Chrysler Engine Features New Combustion Chamber

EXCERPTS FROM PAPER BY

W. E. Drinkard and M. L. Carpentier, Chrysler Corp.

• Paper, "Development Highlights and Unique Features of the New Chrysler V-8 Engine," was presented at the SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 6, 1951. This paper will be published in full in SAE Quarterly Transactions.

THE hemispherical combustion chamber in the new Chrysler valve-in-head, V-8 engine (Fig. 1) was chosen after many studies of both conventional and unconventional engines (some with rotary and sleeve valves) showed that it consistently displayed outstanding performance characteristics. It was considered the ideal solution to the problem of providing those qualities of performance essential to an advanced automotive design by reason of its excellent volumetric and indicated thermal efficiencies, and its ability to maintain these high efficiencies in service.

Shown in Fig. 2 is a sectional drawing of the basic design. The valves are located within a nearly hemispherical cavity in the cylinder head. They are laterally disposed in a plane that passes through the cylinder centerline and is perpendicular to the crankshaft axis. A wide angle is formed between the valve stems. The spark plug is quite centrally located.

Fig. 2 shows that many features of this design are conducive to high volumetric efficiency. The valves are not crowded together, nor surrounded closely by the combustion-chamber walls, and thereby they are fully effective in the flow of the fuel-air mixture and the exhaust gases. Both ports are ideally streamlined with a minimum of directional change. Such port shapes are permitted by the specific location and lateral disposition of the valves. The obvious complete separation of the ports, together with the wide space between the valve seats, assures that the incoming charge picks up a minimum of heat from the hot exhaust. In addition, the flow within the cylinder is not restricted by any barriers or tortuous passages.

It has been consistently observed that excellent volumetric efficiency can be obtained with this design. The well-established principles of gaseous flow most certainly support these observations.

Compression ratio, of course, is an important fac-

WITH the introduction of its 1951 passenger-car models, Chrysler announced a new valve-in-head, V-8 engine of 331 cu in. piston displacement for its larger models. Full-throttle output is specified at 180 hp at 4000 rpm and torque at 312 ft-lb at 2000 rpm. (See Fig. 1.)

The performance, efficiency, durability, and general operating characteristics of this new engine are outstanding, according to the Chrysler engineers who described it at a recent SAE meeting.

In their paper they discussed some features that established its basic design character and are responsible for its high performance. These include: the hemispherical combustion chamber, the 90-deg V-8 cylinder arrangement, new type of valve actuation, water-jacketed throttle-valve body to prevent ice formation, and hydraulic tappets. The authors also cover some of the development problems presented by the new design and give its performance characteristics.

Presented here is the part of the paper that describes the new combustion chamber and gives a brief discussion of some of its outstanding characteristics.

tor that influences the indicated thermal efficiency of an engine. The extensive publicity of recent times has apparently convinced many that it is the only factor, and they erroneously judge the efficiency of an engine by the compression ratio used. Differences exist between combustion-chamber designs that have greater influence on thermal efficiency than do marked changes in compression ratio. An example is presented here that shows the significance of combustion-chamber design upon indicated thermal efficiency.

A single-cylinder engine of 47.2 cu in. displacement, having a stroke bore ratio of 0.94, was used in the evaluation of various combustion-chamber types. The indicated thermal efficiency was determined for each, operating with a compression ratio of 7/1. The full-throttle fuel octane-number requirement was substantially the same for the four chambers that are included in this comparison. Shown in Fig. 3 is the thermal efficiency that was obtained with an L-head, F-head, conventional valve-in-head, and a hemispherical type of chamber. Note the difference between the efficiency of the L-head and the hemispherical design. The F-head is little different than the L-head, and the conventional valve-in-head is midway between the two extremes. All attempts that were made to improve the thermal efficiencies of the L-head and F-head designs by detailed modifications were ineffective. Practical design limitations did not permit any significant physical changes to be made in these designs. The thermal efficiency of the conventional valve-in-head design was improved slightly, but only at the cost of a further reduction in volumetric efficiency and valve durability.

The practical importance of such differences in thermal efficiency may not be apparent; consider, therefore, such differences in terms of compression ratio. Assume that the compression ratio of the L-head, F-head, and the conventional valve-in-head designs is increased for each, to such a value that the thermal efficiencies of all are identical and equal to that of the hemispherical chamber at 7/1 compression ratio. These values have been determined by assuming that the full indicated air-cycle efficiency gain is obtained, which is not always accomplished in practice. In Fig. 4 is shown this comparison, which, for example, discloses that the L-head design requires a compression ratio of 10.0/1 at 1200 rpm, 9.4/1 at 2000 rpm, 8.9/1 2800 rpm, and 8.5/1 at 3600 rpm to equal the efficiency of the hemispherical chamber at a compression ratio of 7/1. The higher compression ratios, required by the less efficient designs, demand of necessity an increase in fuel octane number. The magnitude of this increased requirement will be reflected by comparing the past trends in automotive engine compression ratio and motor fuel knock characteristics. During the past 20 years, for example, the average compression ratio of the American-built passenger-car engine has been increased by only 1.8 units, that is, from about 5.2 to 7.0. This increase was made possible only by the substantial improvement in motor fuel octane number, specifically about 23 numbers in regular-grade, and 16 in premium-grade fuel.

The higher basic thermal efficiency of the hemispherical combustion chamber must result in more efficient overall utilization of fuel, and with distinct gains in other essential performance characteristics.

Test data have shown a pronounced and consistent relationship between surface/volume ratio and indicated thermal efficiency. From a practical consideration, the hemispherical combustion chamber presents the minimum surface area to the volume enclosed, other factors remaining fixed. While we believe that this feature of the hemispherical combustion chamber is primarily responsible for its high thermal efficiency, there are, no doubt, other factors that are also of importance.

The thermal and volumetric efficiencies of an engine are adversely influenced by combustion-chamber deposits. A great number of cases have been observed that show that many engines suffer a full-throttle power loss as great as 10% after only 5000 to 10,000 miles of operation. Most certainly this is a significant loss and means, for example, that a 250 cu in. displacement engine would do the job of a 275 cu in. engine, or that a 3.3/1 axle ratio might be used in place of a 3.7/1, if it were not for this power loss. This power loss is at least equivalent to that resulting from a compression ratio reduction of one full unit, and the accompanying use of a gasoline of about 10 octane numbers lower.

Approximately one-third of this loss is due to a reduction in indicated thermal efficiency and about two-thirds is due to lowered volumetric efficiency. Low surface/volume ratio in the combustion chamber has been observed to be important in minimizing this loss. It can be further reduced by avoiding all scrubbing of the incoming mixture against deposit-coated combustion-chamber surfaces. The hemispherical-chamber design has both low sur-

face/volume ratio and free entry of the fuel-air mixture into the cylinder. It has consistently shown the minimum loss in full-throttle output. L-head and similar designs show substantially higher losses, commonly in the ratio of 3/1. Some conventional valve-in-head designs are no better than the L-head types and the best of these have shown a loss nearly twice as great as the hemispherical design.

Detonation is increased and preignition is incited by chamber deposits. Both of these adverse effects can be avoided by frequent deposit removal. Detonation can be controlled by using a fuel of higher octane number, if available, or by ignition timing retard. This latter course further limits the engine output. Preignition can be controlled for a time by using available higher octane-number gasolines, but it cannot be eliminated by ignition timing retard. Preignition is probably one of the major limiting factors to the use of higher compression ratios in the great majority of existing automotive engines. The hemispherical combustion chamber has consistently shown a minimum in detonation increase and preignition tendency with the accumulation of combustion-chamber deposits.

Valve life and sealing likewise must be excellent in order to assure sustained high efficiency in operation. The statement has been made that the poppet valve represents "a metallurgical triumph over a mechanical monstrosity." While this statement may not be far from the truth, the fact remains that a better substitute is not evident. The job that is required of the valve is tremendous and is often influenced by the combustion-chamber design. The hemispherical combustion-chamber design is most conducive to good valve sealing and life. It is noted in Fig. 2 that the valves need not be crowded together, but, to the contrary, can be spaced quite far apart, still using large valves. Ample metal and coolant can easily be provided between the seats. Note also, that the pronounced separation of the ports permits effective and uniform cooling of the valve seats. These factors, together with the physical shape of the valve deck, are important to the maintenance of round seats. It has been our experience that the stability of the valve seats in this chamber design is excellent.

The hemispherical combustion chamber has shown other advantages, one of which is a very low heat rejection to the coolant. Potentially, this means a smaller, lighter, and less expensive coolant system for an engine of the same power. The lower surface/volume ratio and the extremely short exhaust port that naturally result are probably responsible.

The specific heat rejection has consistently been found to be higher in all other conventional types (about 40% higher in the better L-head designs and at least 20% higher in the best of the conventional valve-in-head types.)

The hemispherical combustion chamber, as a result of these observations, was selected for use in the new Chrysler V-8 engine because it appeared to be the most practical design that assured the performance gains that we sought to attain.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

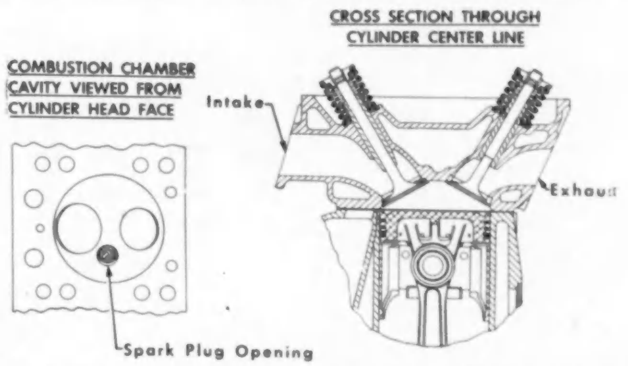

Fig. 2—Cross-section showing hemispherical combustion chamber

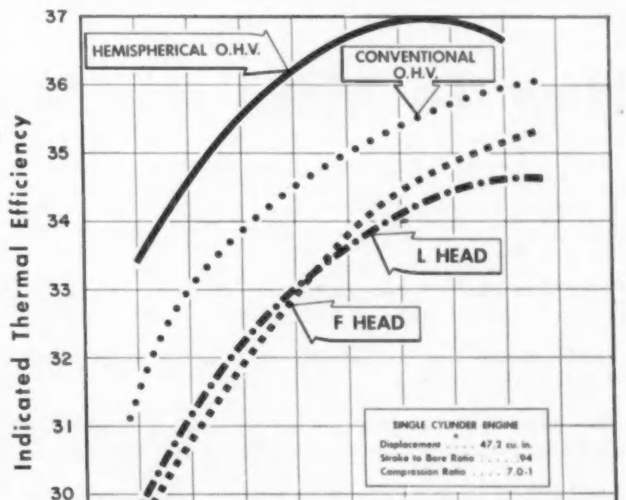

Fig. 3—Curves showing influence of combustion-chamber design on indicated thermal efficiency

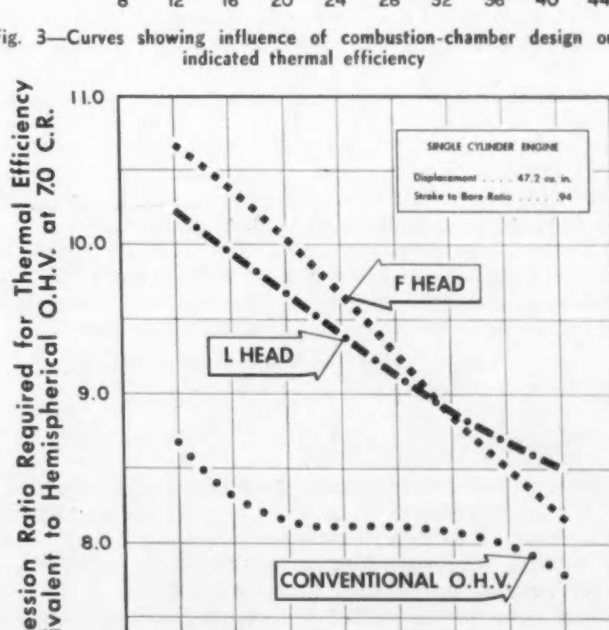

Fig. 4—Compression ratios for equivalent thermal efficiency

Facts for Fleet

How To Make the Most of Octane Numbers

FLEET operators can take two steps to make best use of the antiknock quality of present fuels:

1. Correct the conditions that cause some units to have high octane requirements.

2. Adjust the remainder of the fleet to take better advantage in power and economy of the fuel used.

Octane number requirements of commercial vehicles spread over at least a 30-octane-number range, surveys show. A gasoline which satisfied only vehicles having low requirements would fate most engines to low power, inefficiency, and—after long periods of heavy knock—to such troubles as cracked pistons.

But a fuel of octane number high enough to eliminate knock completely in all commercial vehicles would saddle low-octane-requirement vehicles with unnecessary expense. There must be a reasonable compromise if manufacturing cost is to be kept at the low level demanded by the trade today.

Best choice for fleet use, currently at least, is leaded regular-grade gasolines. While their ratings differ in different parts of the country, they fall generally between 81 and 87 Research octane.

Engines which knock on regular-grade gasoline can be improved by these four measures:

1. Correct ignition timing.

Production tolerance on distributors is ± 2 deg, which is equivalent to an octane-number variation of 4 units. Production tolerances should be reduced to within ± 1 deg. Common timing variations of much greater magnitude originate with bent shafts, faulty cam lobes, cocked plates, and general wear; these flaws are examples—they can raise octane requirement of individual cylinders 5–10 octane numbers above the others.

These plus improper advance with speed and advanced basic timing can raise antiknock requirement by 5–15 octane numbers. Each degree overadvance increases octane requirement approximately 1 unit.

2. Lower excessive temperatures of parts contacting the gaseous charge.

Clean out clogged water jackets. Relieve poor valve cooling, valve leakage, excessive manifold heat, and causes of too-hot inlet charge.

The fact that a 10-deg increase in coolant temperature is equivalent to an increase of 1 octane number in passenger car requirement illustrates the importance of moderating temperatures.

3. Clear away combustion-chamber deposits.

Try a few full-throttle uphill climbs and a high-speed run. Occasional full throttle hot runs may do enough in reduction of deposits to save expensive overhaul or carbon removal operations.

Deposit accumulation in light-duty commercial trucks may add 5–15 octane numbers to the quality requirement.

4. Improve carburetion.

Correct worn carburetor parts, poorly fitting gaskets, manifold deposits, and improperly functioning valves. These and other faults tend to upset mixture distribution and produce lean cylinders. Lean mixtures promote knock.

These measures should bring the 10–15% of troublemakers in a fleet to satisfactory nonknocking performance on regular-grade gasoline.

The remaining 85–90% of commercial engines are not limited in performance by the antiknock quality of regular grade. Perhaps they can be adjusted to

Continued on Page 31

Operators . . . .

BASED ON PAPER BY

G. A. Round, Chief Automotive Engineer, Lubricating Department

and

W. S. Mount, Manager, Product Engineering Division, Gasoline & Fuel Oil Department

Socony-Vacuum Oil Co., Inc.

• Paper "What the Fleet Operator Should Know about Fuels and Lubricants" was presented at the SAE National Transportation Meeting, New York, Oct. 18, 1950. This paper was printed in full in the April issue of SAE Quarterly Transactions. Complete paper covers diesel fuels and gear lubricants as well as gasoline and engine oils. Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.

What Engine Oil Types Mean

THERE are three basic types of engine oils available today, one type having five subtypes:

1. Regular Type
2. Premium Type
3. Heavy-Duty Type
   - (a) U. S. Army Specification 2-104B
   - (b) U. S. Navy Specification 14-0-13a (also called 9000 Series)
   - (c) Supplemental List 2 (also called Superior Lubricants and Series 2)
   - (d) Supplemental List 1
   - (e) MIL-0-2104

SAE Handbook defines the three basic types this way:

"*Regular Type* . . . designates motor oil generally suitable for use in internal combustion engines under moderate operating conditions."

"*Premium Type* . . . designates motor oil having the oxidation stability and bearing-corrosion preventive properties necessary to make it generally suitable for use in internal combustion engines where operating conditions are more severe than regular duty."

"*Heavy-Duty Type* . . . designates motor oil having the oxidation stability, bearing-corrosion preventive properties, and detergent-dispersant characteristics necessary to make it generally suitable for use in both high-speed diesel and gasoline engines under heavy-duty service conditions."

Regular Type

In practice, regular type means mineral oil without anything added to increase natural resistance to oxidation or to impart detergent-dispersive characteristics. Regular-type oils do commonly contain an additive to lower pour point, sometimes one to govern color, and, in special cases, material to prevent scuffing during break-in. Physical characteristics and performance properties vary widely, depending on crude source and refining methods.

Until the early nineteen-thirties, regular-type oils were the only type sold.

Premium Type

Premium-type oils are combinations of well-refined regular-type oils plus additives to give increased resistance to oxidation. The aim is satisfactory performance with respect to copper-lead bearing corrosion and deposit formation in a gasoline engine in fairly hard service. Premium-type

oils are expected to perform satisfactorily in the CRC L-4 Test Procedure for Determining Oxidation Characteristics of Heavy-Duty Crankcase Oils. This is the 36-hr Chevrolet engine test.

There is nothing in the definition of premium-type oils to preclude their containing detergent additives. Many do, especially those sold at filling stations. However, fleet operators who want stable (that is, oxidation-resistant) non-detergent oil will find that in the premium-type group of oils.

Heavy-Duty Type

Heavy-duty type oils all have an oxidation inhibiting additive to improve oxidation stability and prevent bearing corrosion, and a detergent to minimize deposits. This type has been in use for about ten years. The five performance levels of heavy-duty type oils evolved during the last five years.

Specification 2-104B Oils—Back in 1942 when this specification was first issued by the Army, it required oils to pass five engine tests to qualify. These were the 480-hr L-1 and the 3-hr L-2 tests in single-cylinder Caterpillar test engines, the L-3 test in a four-cylinder Caterpillar engine, the L-4 test in the Chevrolet engine, and the 500-hr test in a General Motors diesel. Experience eventually showed that oils which passed the L-1 and the L-4 tests would also pass the L-5 test. The L-5 test was dropped, as were the L-2 and L-3.

Over 700 brands of engine oils qualified under Specification 2-104B. But wide differences exist between their ease of cranking, fluidity at low temperatures, oxidation stability, bearing-corrosion prevention, deposit-forming tendencies, and oil-consumption rates. There are three reasons for the variations in quality:

1. Competitive bidding required for government contracts tended to force quality down to the minimum.

2. At the time the L-1 procedure was standardized, it was not realized how seriously fuel character can effect deposit formation. The L-4 procedure allows use of rather high-quality fuels. Testers soon learned that by using a high-quality fuel, tests would produce acceptable piston conditions with an engine oil which would not pass with a poorer fuel. The resulting tendency was to use the best fuel and the least amount of oil additives giving a piston acceptable to the Ordnance Review Board.

3. The Ordnance Review Board became more critical as time went on. But oils qualified under the early scrutiny were permanent members of the 2-104B club. Some were improved and requalified as the Board's requirements grew more stringent—some were not.

Although Specification 2-104B has been replaced by MIL 0-2104, oils meeting 2-104B are giving excellent results commercially and outsell other heavy-duty types combined.

Specification 14-0-13a Oils—The Navy set up a specification of its own requiring the L-1 and L-4 tests used with Army Specification 2-104B plus a 500-hr test in a submarine diesel rather sensitive to ring sticking. Consequently, oils meeting this specification, commonly known as 9000 Series oils, have a somewhat higher performance level than those qualifying only under 2-104B.

Only 18 oils have qualified under the Navy specification, but this is not due solely to the qualification requirements. Cost and time required are high. Sometimes it takes two years to qualify an oil under 14-0-13a.

Supplement 2 Oils—Several years ago, diesel operators complained of ring sticking and high cylinder and ring wear, despite use of 2-104B oils. The troubles were attributed to sulfur in the fuel.

To prevent them, Caterpillar established new requirements for oils seeking Caterpillar approval. Essentially, the requirements were that an oil must first give a clean piston and low wear rate in a 480-hr test in their supercharged single-cylinder test engine using fuel of 1% sulfur minimum. Successful oils then must perform satisfactorily in a multi-cylinder supercharged engine test, and finally in a field test. Caterpillar calls oils satisfying these requirements Superior Lubricants (Series 2).

To accommodate industry and aid development of improved lubricants, the office of the Chief of Ordnance undertook qualification of these higher-quality oils. Actually, the Army required only the Chevrolet L-4 test and the Caterpillar 480-hr supercharged single-cylinder diesel test using fuel with 1%-minimum sulfur content. They did not require the multi-cylinder supercharged diesel and field tests stipulated by Caterpillar.

Ordnance released names of qualified brands on a list supplementing the list of qualified 2-104B oils. The list was "Supplemental List 2," and the oils on it became known as Supplement 2 oils.

Practically speaking, Supplement 2 and Superior Lubricants (Series 2) possess the same performance properties. Caterpillar accepts Supplement 2 oils as satisfactory for its engines. They are recommended for all naturally aspirated models using fuel of 0.5% sulfur or greater and for supercharged engines with any fuel.

Supplement 1 Oils—Some oil suppliers wanted to raise the performance level of their 2-104B-type oils. Yet they felt that lubricants of the high additive content and consequent high cost of Supplement 2-type oils were unnecessary for many applications.

Out of this need grew an intermediate type tested for qualification in the nonsupercharged Caterpillar test engine with a fuel having a minimum sulfur content of 1%.

Ordnance also qualified this type and released the brand names on "Supplemental List 1." These are the Supplement 1 oils. Like Specification 2-104B and Supplemental List 2, Supplemental List 1 has been superceded by MIL-0-2104.

MIL-0-2104 Oils—On August 4, 1950, military specification MIL-0-2104 took effect. Its requirements are higher than for 2-104B but less demanding than Supplements 1 and 2.

To qualify under MIL-0-2104, an oil must perform satisfactorily in a 480-hr test in the nonsupercharged Caterpillar test engine on a fuel of 0.35% minimum sulfur content.

The new MIL specification will save taxpayers' dollars and conserve additive materials because it permits lower additive levels than either of the Supplements. Most Army ground-force equipment is gasoline powered, anyway, and does not require the higher additive level.

Current Army policy concerning oil qualifications and publication of qualification lists is this:

1. Lists of qualified oils with qualification numbers are no longer released for publication, as formerly.

2. Manufacturers and others having a legitimate need for a list of oils qualified under MIL-0-2104 may obtain it.

3. Manufacturers may not publish the list as an Ordnance list or with qualification numbers shown.

4. If a manufacturer so desires, he may publish a list of oils which he believes satisfy MIL-0-2104.

Only experience can answer the question of which one of the five categories is best for operation that does require some kind of heavy-duty oil. Some oil companies have advocated Supplement 2-type oils for all diesels using high-sulfur fuels and Supplement 1 oils for very heavy-duty service of gasoline engines and for diesels using low-sulfur fuels.

Some lubrication experts also recommend these oils for stop-and-go service, where cold sludge, ring clogging, and rapid wear are a problem. Here the theory is that the strong dispersive action of the high-additive-content oils prevents sludge formation and the additive neutralizes the acid products of combustion that promote wear. However, it remains to be shown how a large concentration of additive, which itself is a powerful emulsifying agent, can act to prevent emulsification of oil with water, soot, and other foreign materials resulting from cold operation.

In choosing a heavy-duty oil, operators should remember that not all diesel engines appear to be equally sensitive to fuel differences, including sulfur content. Some may not require high-additive-content oils. Combustion characteristics and design factors make the difference. Besides, the large ash residue from combustion of the additives contributes to deposit formation in some engines. The deposits can cause serious wear as well as shorten valve and spark plug life.

How To Make the Most of Octane Numbers

Continued from Page 28

give more power and better economy with current regular grades.

Of course, no engine should be brought right up to the limit of gasoline quality. Allowance should be made for normal day-to-day fluctuations in engines' antiknock requirements. Deposits accumulated in 5000 miles may elevate octane requirement 5–10 numbers after the initial adjustment. Each 1000-ft increase in altitude decreases requirement by 1–3 numbers. Normal barometric pressure swings over the year correspond to 1–3 octane numbers. Drop in humidity from 90 to 20% at 70 F amounts to 4 octane numbers. The change from winter to summer temperatures is often estimated at 2 octane numbers.

Bearing in mind the allowance for these variables, it may be worth while to consider several measures to gain power and economy in low-requirement engines. The measures are:

1. Advance spark timing. Bring the timing up to standard first. Then try advancing it several degrees beyond standard, but not beyond optimum performance. Be sure that the manifold vacuum control functions properly for the full speed and power range. Correct basic timing alone is not enough.

2. Return overly rich carburetor settings to normal.

3. Set cooling-system thermostats for slightly higher coolant temperatures. This reduces friction.

Point 2 obviously will cut fuel consumption, and Point 3 will improve power as well as economy.

The authors suggest the possibility that commercial engines could be designed and built at the factory in anticipation of one major compression ratio modification during the engine's average ten-year life. They suggest that the low requirement engines, as well as others, might be modified, using conversion kits engineered and manufactured by the engine builder so as to take advantage of improved gasolines as they become available during the life of the engine. Whether or not compression ratio adjustments should be made without this careful preparation is somewhat controversial. In any case, steps of this kind should be taken only with assurance from the engine manufacturer that his equipment will withstand the higher stresses involved.

Willett

BASED ON PAPER BY

A. Walter Neumann,

Director of Maintenance, The Willett Co.

• Paper "Maintenance Savings Accomplished Through an Integrated Plan of Precision Testing and Adjustment to Manufacturers' Standards" was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

BY revising its preventive maintenance system, the Willett Co. has saved over $30,000 in one year.

The new preventive maintenance program calls for two inspections, an "A" inspection performed at 1000–1500-mile or five-week intervals and a "B" inspection performed at 6000-mile or six-month intervals. Figs. 1 and 2 show the inspection lists.

Inspected vehicles are spot checked to insure that the mechanic follows instructions and incidentally to determine maintenance intervals for future revisions of the system. Fig. 3 shows the Spot Check Report.

All three forms are altered as experience uncovers better procedures or clearer wordings for instructions. So the forms are reproduced from typewriting.

The "A" inspection takes about 1.5 man-hours and the "B" inspection takes about 4.5 man-hours. Respectively, they correspond roughly to the "B" and "C" inspections of the SAE Recommended Practice on Preventive Maintenance and Inspection Procedure contained in SAE Handbook.

A light truck fitted out as a mobile inspection and maintenance shop brings the "A" inspection to the 200 Willett vehicles in outlying garages. The truck contains an air compressor, electric power tools, one 100-lb drum of chassis grease and another of gear lubricant, parts bins, a bench with a vice, and an air line for inflating tires.

Incentive for developing this new two-inspection system was the marked increase in man-hours spent on preventive maintenance. Willett began its PM program back in 1934 with a monthly or 1500-mile inspection that then took 1 or 1½ man-hours. By 1949, the combination of greater complication and less accessibility in vehicles brought the figure up to 5 man-hours per inspection.

Postwar reconsideration of the initial PM program showed two defects:

1. Some items didn't need attention as often as

Fig. 1—"A" inspection form

Vehicle No.________

Date________

THE WILLETT COMPANY
CHICAGO 7

INSPECTION AND SERVICE REPORT FOR TRUCKS, TRACTORS, BUSES, PASSENGER CARS AND GASOLINE OR DIESEL POWERED TRANSPORTS.

"A" INSPECTION

I. CAB-BODY-CONTROLS AND ACCESSORIES

____1. Test brake pedal travel - Free travel should not be more than 2/3. *Adjust brakes if necessary.
____2. Fill Master Cylinder. If fluid is lower than ½ full, report to foreman.
____3. Test clutch pedal play and adjust if necessary.
____4. Test horns, electric and air. *Adjust if necessary.
____5. Test windshield wipers. Replace blades as necessary.
____6. Inspect rear view mirrors - tighten arms.
____7. Check all gauges for proper operation.
____8. Inspect headlights, running lights, stop lights and fog lights. Replace bulbs or *sealbeams as necessary. *Make necessary repairs. *Eliminate shorts (use voltmeter)
____9. Inspect for accident damage and any loose, broken or defective parts.

II. LUBRICATION - (ACCORDING TO LUBRICATION CHART)

____1. Lubricate unit thoroughly. Free up frozen shackles and replace broken fittings.
____2. Fill transmission to level. Fill differential to ½" below filler plug. (If more than 1 lb. of lubricant is required report to foreman)
____3. Send OIL SAMPLES to Lab. when so indicated. *Drain or flush per Lab. report. If oil is drained be sure to refill crank case and check oil stick.
____4. *Change oil filter ONLY when laboratory report calls for Oil Drain and Flush.
____5. Oil all door and gate hinges and locks.

III. MOTOR

____1. Visually inspect battery.
  ____a. Check water level. Fill to 3/8" over plates with DISTILLED WATER ONLY.
  ____b. Inspect for dirty or acid condition. Clean with soda and brush if necessary. Grease terminals.
  ____c. Check battery and cables with Voltmeter. (Battery to ground and battery to starter)
____2. Attach Tach Dwell Indicator.
  ____a. Check for point resistance.
  ____b. Start engine - check dwell (Correct if necessary)
  ____c. Adjust carburetor idle speed. Tighten all loose screws and nuts. *Test and make major adjustment to carburetor if necessary.
  ____d. Check governor and set if necessary.
____3. Time engine with neon timing lights.
____4. Check fuel filter and fuel pump screens and bowl. *Clean if necessary.
____5. Tighten radiator hose connections and check hoses for collapsed or rotten condition.
____6. Fill radiator and check cooling system for leaks and overheating. NOTE quantity of water added. TEST AND ADD ANTI-FREEZE IN WINTER.
____7. Inspect fan assembly and fan belts. Adjust fan belts to ½" play with ruler. *Renew belts when necessary.
____8. Inspect motor for oil leaks NOTING valve covers, crank case gaskets, timing case seal, fuel pump block gaskets, rear main bearing seal, oil filter cap, oil filter block and cap gaskets and flexable oil lines.
____9. Lubricate generator, starter, carburetor linkage, governor shaft, and distributor shaft. (USE PROPER LUBRICANT - DO NOT USE TOO MUCH)
____10. Tighten or replace all loose belts, screws, and nuts.
____11. Inspect and check operation of Block Heater. *Make necessary repairs.

IV. RUNNING GEAR

____1. Inspect all springs for broken or shifted leaves.
____2. Check tie-rod, drag link, drag link springs and steering assembly for play. (Shake test)
____3. Check drive line, universal joints and pinions for play. (Shake test)
____4. Visually check front wheel alignment, being careful to note front tire wear and mounting. *Adjust toe if necessary. Report bad alignment condition.
____5. Tighten or replace all loose or missing bolts, screws and nuts.

V. TIRES

____1. Tighten axle flange nuts with torque wrench (see specifications).
____2. Inflate tires and fill out report. TIRES MUST BE COLD.
____3. Replace valve cores as necessary. Install missing valve caps.
____4. Tighten all lugs and note broken studs or loose rims.

VI. SAFETY EQUIPMENT

____1. Inspect and adjust drag chains. *Replace if necessary.
____2. Refill CO_2 and Pyrene Fire Extinguishers.
____3. Check flags and flares. *Replace as necessary (require 3 of each).
____4. Inspect first aid kits. *Replace missing items.

VII. ADDITIONAL FOR REFRIGERATED VEHICLES

____1. Check oil level in condensing unit.
____2. Check sight glass for quantity of refrigerant.
____3. Lubricate entire refrigeration unit thoroughly.
____4. Check complete electrical circuit.
____5. Inspect fan assembly and fan belts. Adjust for belts to ½" play with ruler. *Renew belts when necessary.
____6. Check and tighten loose motor and compressormounts.
____7. Check compressor compartment for looseness and wear.
____8. Check fuel bowl on gas operated engines. *Clean if necessary.

VIII. ADDITIONAL FOR GASOLINE OR DIESEL POWERED TRANSPORTS

____1. Blow out air tanks. *Replace compressor if excessive oil is found.
____2. Inspect safety valves and shut-off valves for leaks. *Repair or replace as necessary.
____3. Check dome covers for operation and leaks. *Replace gaskets as necessary.
____4. Fill alcohol injectors with Methonol in winter.
____5. Disconnect Weber Hitch to inspect and pack with wheel bearing grease.
____6. Check and *adjust tappet clearance on all overhead valves.
____7. Adjust slack adjustors on all air brakes.

NOTE: *(1) All items marked with an asterisk (*) means that parts must be replaced or repaired when necessary. Use time schedule manuals or Willett Company Supplements for proper time allowances.
(2) Report all unusual conditions to your foreman.

Streamlines Preventive Maintenance

Inspection and Service Report for Trucks, Tractors, Buses and Gasoline Powered Transports - "B" Inspection

Vehicle No.____________

Date____________

I. CAB-BODY-CONTROLS AND ACCESSORIES

____1. Test clutch pedal play and adjust if necessary.
____2. Test horns - electric and air. *Adjust if necessary.
____3. Test windshield wipers. Replace blades as necessary.
____4. Inspect rear view mirrors - tighten arms.
____5. Check all gauges for proper operation. Use screen to adjust headlights.
____6. Inspect headlights, running lights, stop lights, fog lights. Replace bulbs or *sealbeams as necessary. *Make necessary repairs. *Eliminate shorts. (Use voltmeter)
____7. Inspect cab heaters and all bus heaters. Tighten all hose connections and inspect all hoses for collapsed or rotten condition.
____8. Inspect cab seat cushions and bus passenger seats and aisle seats.
____9. Inspect bus luggage racks for any loose, broken or defective parts.
____10. Inspect for accident damage.
____11. Check condition of paint and lettering in spaces provided.

__OK __Needs Touch Up __Needs clear coat __Needs paint

II. LUBRICATION - (ACCORDING TO LUBRICATION CHART)

____1. Lubricant unit thoroughly. Free up frozen shackles and replace broken fittings.
____2. Fill transmission to level. Fill differential to ½" below filler plug. (If more than 1 lb. of lubricant is required report to foreman)
____3. Send oil samples to Lab., drain or flush per Lab. Report. If oil is drained be sure to refill crank case and check oil stick.
____4. Change oil filter.
____5. Oil hydrovacs. (Do not oil Rubber Diaphram Type)
____6. Oil all door and gate hinges and locks.

III. MOTOR

____1. Perform all tests and make necessary corrections in accordance with SUN DIAGNOSIS REPORT AND INSTRUCTION MANUAL except items 18 to 21 inclusive.
____2. NOTES: 1. Fuel pump - test FLOW of fuel pump instead of pressure. (Should be 1 pint to 45 sec.)
2. If Cylinder Balance Test is OK, omit Compression Test. *Additional for compression test.
3. *Perform item 17 only if it is necessary to remove distributor.
____a. Inspect battery for dirty or acid condition. Clean with soda and brush. (Grease terminals)
____b. Clean fuel filter and fuel pump screens and bowl.
____c. Tighten down intake manifold and carburetor.
____d. Remove and clean oil breather cap and AIR CLEANER on engine and air compressor.
____e. Clean and refill oil bath to proper level with engine oil.
____f. Check governor and set if necessary.
____2. Check valve tappet clearance on overhead valves only. (See chart or Mfg. Specs.) *Adjust if necessary.
____3. Tighten radiator hose connections and check hoses for collapsed or rotten condition.
____4. Fill radiator and check cooling system for leaks and overheating. NOTE quantity of water added. TEST AND ADD ANTI-FREEZE IN WINTER.
____5. Inspect fan assembly and fan belts. Adjust fan belts to ½" play with ruler. *Renew belts when necessary.
____6. Inspect motor for oil leaks NOTING valve covers, crank case gaskets, fuel pump block gaskets, rear main bearing seal, oil filter cap, oil filter block and cap gaskets and flexable oil lines.
____7. Lubricate generator, starter, carburetor linkage, governor shaft and distributor shaft. (USE PROPER LUBRICANT - DO NOT USE TOO MUCH)
____8. Tighten cylinder head bolts and spark plugs with torque wrench according to prescribed specifications.
____9. Tighten or replace all loose bolts, screws and nuts.
____10. Inspect and check operation of Block Heater. *Make necessary repairs.

IV. CHASSIS

____1. Check fifth wheel on tractor noting jaws, rubbers, safety lock and operating mechanism.
____2. Tighten hold-down bolts and stops on tractor fifth wheel.
____3. Tighten cab body bolts and clamps.
____4. Check frame, spring hangers etc., for cracks, loose rivets or bolts.
____5. Tighten fuel tank brackets. *Replace felts if necessary.
____6. Tighten radiator hold-down bolts and stay rods.
____7. Inspect exhaust system for leaks, loose joints and mountings.
____8. Tighten or replace all loose bolts, screws and nuts.

V. RUNNING GEAR

____1. Jack up all wheels and check for play. Adjust front wheel bearings as necessary. *Adjust rear wheel bearings if necessary.
____2. Fill Master Cylinder. If fluid is lower than ½ full, report to foreman.
____3. Check and adjust brakes as necessary. (Minor adjustment) Use feeler gauge at both cam end and anchor pin end (see charts). Tighten loose backing plates.
____4. Check for play in kingpins. *Replace as necessary.
____5. Check tie-rod, drag link, drag link springs, and steering assembly for play, (shake test). *Replace broken drag link springs.
____6. Check drive lines, universal joints and pinions for play (shake test).
____7. Inspect all springs for broken or shifted leaves.
____8. Tighten all spring clips and "U" bolts (check center bolts).
____9. Check TOE and adjust if necessary. Visually inspect front wheel alignment, being careful to note front tire wear and mounting. Report bad alignment condition.

VI. TIRES

____1. Tighten axle flange nuts with torque wrench (see chart).
____2. Inflate tires and fill out report. TIRES MUST BE COLD.
____3. Replace valve cores as necessary. Install missing valve caps.
____4. Tighten all lugs and note broken studs or loose rims.
____5. Measure tires with tape. If mismated, report on tire ticket.
____6. Check tires for cuts or bruises and make report.

VII. SAFETY EQUIPMENT

____1. Inspect and adjust drag chains. *Replace if necessary.
____2. Refill CO_2 and Pyrene Fire Extinguishers.
____3. Check flags and flares. *Replace as necessary (require 3 of each).
____4. Inspect first aid kits. *Replace missing item.

VIII. ROAD TEST

____1. Road test completed unit - one mile.
____2. Make all necessary adjustments.

IX. ADDITIONAL FOR REFRIGERATED VEHICLES

____1. Check oil level in condensing unit.
____2. Check sight glass for quantity of refrigerant.
____3. Lubricate entire refrigeration unit thoroughly.
____4. Fill gas engine crank case. *Change and flush when called for on truck engine. NOTE: Do not remove compressor crank case plug. This unit is sealed.
____5. Check complete electrical circuit.
____6. Inspect for assembly and fan belts. Adjust fan belts to ½" play with ruler. *Renew belts when necessary.
____7. Blow out radiator fins with air.
____8. Check and tighten loose motor and compressor mounts.
____9. Check compressor compartment for looseness and wear.
____10. Clean fuel bowl on gas operated engines.
____11. Clean and set spark plug gap on gas operated engines.

X. ADDITIONAL FOR GASOLINE POWERED TRANSPORTS

Lubrication

____1. Jack up semi and four wheeler to grease and inspect fifth wheel, roller circle and kingpins.
____2. Disconnect Weber Hitch to inspect and pack with wheel bearing grease.
____3. Check pintle pin. *Replace if worn. Secure safety chains or other apparatus so that pintle pin can under no circumstances touch the ground in case of break-away.

Running Gear

____1. Check all air brake tubing, hoses, trailer connections and diaphrams for leaks with soap suds. *Repair if necessary.
____2. Blow out air tanks. *Replace compressor if excessive oil is found.

Chassis

____1. Inspect safety valves and shut-off valves for leaks. *Repair or replace as necessary. Check inside of tanks, and remove foreign matter.
____2. Check dome covers for operation and leaks. *Replace gaskets as necessary.
____3. Install caps and chains on pipe outlets making sure that sealing lugs are attached.

NOTE: *(1) All items marked with an asterisk (*) means that parts must be replaced or repaired when necessary. Use time schedule manuals or Willett Company Supplements for proper time allowances.
(2) Report all unusual conditions to your foreman.

Fig. 2—"B" inspection form

THE WILLETT COMPANY
CHICAGO 7

Date_________19__

SPOT CHECK REPORT

To:_________________ Department_________________
(Foreman in charge)

The spot check of vehicle No.____ on Shop Order No. ____ shows that the following work was not properly performed.

Please have the mechanics in question make the necessary corrections.

Points have not been awarded for the work in question.

Report to Larry Kane, Superintendent of Maintenance, after the work has been properly performed.

☐ Spot Check showed vehicle to be o.k.

Howard L Willett Jr
Howard L. Willett, Jr.
Executive Vice President

To: Superintendent of Maintenance

The corrections are understood and all work has been properly performed.

Mechanic_________________ Mechanic_________________

Date report rec'd_________19__ Date work completed_____________19__

____
Signature of Foreman in Charge

Fig. 3—Spot Check Report

FLEET DIAGNOSIS REPORT

VEHICLE NO.	TYPE	MILEAGE
DATE	ORGANIZATION	

For use with
Sun Universal Diagnosis Tester

	OK	SEE OTHER SIDE		OK	SEE OTHER SIDE
1. Battery Visual Inspection			13. Compression Test		
Cell No. 1 Cell No. 2 Cell No. 3			Cyls. 1___ 2___ 3___ 4___ 5___ 6___ 7___ 8___		
Battery Capacity			Valve Condition		
2. Cranking Voltage			Piston & Ring Condition		
Battery Cables. Starter Switch			Cyl. Head Torque		
3. Starting Motor Amperage Draw			14. Coil Capacity & Primary Circuit		
4. Generator Visual Inspection			Coil Secondary Resistance		
Generator Output			15. Condenser — Resistance		
Generator Circuit Resistance			Capacity		
Generator Relay (Closes / Opens)			Insulation		
Current Regulator (Amperes)			16. Distributor or Magneto— Visual Inspection		
Voltage Regulator (Volts)			Distributor Cap		
5. Engine R.P.M.			Rotor		
Distributor Point Dwell			Ignition Cables		
6. Spark Timing			17. Distributor or Magneto Tests (removed)		
7. Vacuum Reading			Contact Point Resistance		
8. Milliampere 1___ 2___ 3___ 4___ at Spark Plugs 5___ 6___ 7___ 8___			Spring Tension		
9. Cyl. Balance			Point Dwell — Cam		
10. Carburetor			Shaft — Bushings		
Test Manifold Heat Control Valve			Automatic Advance		
Idle Speed Circuit			Vacuum Advance (After reinstalling Distributor recheck Dwell & Timing)		
Intermediate Speeds			18. Radiator — Water Pumps — Hose		
High Speed Circuit			19. Exhaust System		
Accelerating Pump			20. Other Electrical Circuits		
Air Cleaner			Lights		
Intake Manifold			Horn		
Choke			Accessories		
11. Fuel Pump Pressure			21. Safety Tests		
Vacuum			Windshield Wipers		
			Steering		
			Tires		
			Brakes		
12. Spark Plugs			22. Speedometer		

Fig. 4—Fleet Diagnosis Report

they were getting it. For example, it wasn't necessary to tighten body bolts; hold-down bolts for cab, fenders, windshield, and radiator; and stay-rods each month. Nor was it essential to adjust the wheel bearings; remove, clean, and adjust spark plugs; tighten cylinder head bolts; and take compression readings after this short interval. Such unnecessary work increased costs and encouraged mechanics to be careless.

2. There was no accurate method of checking carburetor and ignition-system adjustment. For example, if a hydrometer registered the normal reading, mechanics assumed that the generator, battery, and entire primary electrical system were all right. But sometimes the battery would not start the engine the next morning because of faulty connections.

To correct the state of overmaintenance, Willett set out to determine (1) what items needed inspection, (2) the nature of the service required, and (3) the optimum time interval between servicings. Qualified inspectors, using the original inspection list, spot checked vehicles for six months to find these facts for chassis, tires, safety equipment, controls, and other items.

About the time Willett decided to revise the PM system, representatives of the Sun Electric Corp. called to discuss their newly developed engine-test equipment. As a result, Sun experts cooperated in establishing standards and allowable tolerances as well as inspection intervals for items that could be tested with their equipment. And the equipment is used in both the "A" and "B" inspections. Items 1-17 of the Sun Electric Fleet Diagnosis Report (Fig. 4) are part of the "B" inspection.

To fit the new PM system into Willett's already established incentive plan, new time standards for each type of vehicle were determined for the "A" inspection and the "B" inspection. Allowances for the "A" inspection are 1.4 man-hours for conventional trucks and tractors, 1.6 for COE trucks and tractors, 1.5 for conventional buses, 1.6 for COE buses, 1.1 for panel trucks, 1.2 for Metro trucks, 0.8 for passenger cars, 0.5 for single-axle trailers, and 0.8 for tandem axle trailers. Allowances for the "B" inspection are 4.2 man-hours for conventional trucks and tractors, 4.5 for COE trucks and tractors, 4.7 for conventional buses, 5.0 for COE buses, 3.2 for panel trucks and Metro trucks, 2.2 for passenger cars, 0.7 for single-axle trailers, and 1.2 for tandem-axle trailers.

Records of comparable three-month periods under the old and the new PM programs show that the new one reduced parts used, road calls, and labor, even though mileage rose 15%. For example, maintenance required 63 instead of 278 contact points, 234 instead of 375 battery recharges, 98 instead of 220 battery rebuilds, 251 instead of 435 oil filters, 3 instead of 9 six-volt coils, and 10 instead of 16 six-volt regulators. Road calls fell off 13.8%. Preventive maintenance labor decreased 34.1%, mechanical and road-call labor 12.2%, and the tire-repair labor 8.3%—making a reduction in total mechanical and maintenance labor of 16%.

These reductions in parts and labor saved a total of $30,750 in .naintenance costs.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Alloy Aluminum For Automobile Bodies

BASED ON PAPER BY

E. C. DeSmet, Willys-Overland Motors, Inc.
J. H. Dunn, Aluminum Co. of America
E. J. Zulinski, Progressive Welder Co.
C. J. Schmidt, Goodyear Aircraft Corp.

• Paper "A Modern All-Aluminum Body Development for Production" was presented at the SAE Annual Meeting, Detroit, Jan. 11, 1951.

RECENT development work indicates that alloy aluminum is a well-suited material for automobile bodies. Forming and processing in quantity production seem to offer no serious difficulties. And noteworthy advantages of weight saving and corrosion resistance—reflected in terms of better vehicle performance, increased operating economy, longer life, lower maintenance cost, and easier handling of the finished product—more than compensate for higher material and processing costs.

To fully explore design and construction problems, a joint research group—organized on a cooperative basis to make this study—engineered and built a complete automobile body. Sole purpose of the project was to determine what could be done with aluminum in body structures by taking advantage of latest developments in modern alloys, new welding equipment, and up-to-date fabrication methods and techniques. There was no thought of designing a new type of automobile.

The study was handled strictly from a practical point of view. Each part was designed so that it would lend itself to efficient aluminum fabrication. Actual fabrication and assembly operations were performed with production-type tooling, under conditions as nearly representative as possible of large quantity production requirements.

Selection of material was the initial problem. Two general types were considered. The first, referred to as Class I, consists of alloys which acquire higher physical properties by cold-working. The second type, or Class II, acquires higher properties by heat-treating. Table 1 lists typical properties of certain alloys in each class.

The following summary was made of the advantages and disadvantages of each alloy:

4S Alloy—(Class I)

ADVANTAGES: Low price, fair properties in intermediate tempers, good resistance to corrosion, good workability, good weldability.
DISADVANTAGES: Difficult to obtain uniform or high properties throughout a drawn piece.

Alclad 24S Alloy—(Class II)

ADVANTAGES: Ability to obtain high and uniform properties by heat-treating, good resistance to corrosion when properly quenched, best fatigue properties, good spot-welding characteristics.
DISADVANTAGES: Higher raw material cost, higher cost of heat-treatment, poor weldability by torch or arc methods.

61S Alloy—(Class II)

ADVANTAGES: Ability to obtain high and uniform properties by heat-treating, good weldability, slightly less cost than Alclad 24S for raw material, good resistance to corrosion.
DISADVANTAGES: Necessity of aging operation in cases where the best attainable properties are required in parts that must be produced in forming operations.

On the basis of this study, the 4S alloy appeared to be the most suitable material. However, the question whether or not a body made from it would exhibit sufficient ruggedness for normal automobile operation remained to be answered. To make the investigation more complete, another body was built using Alclad 24S as the basic material. (Alclad 24S

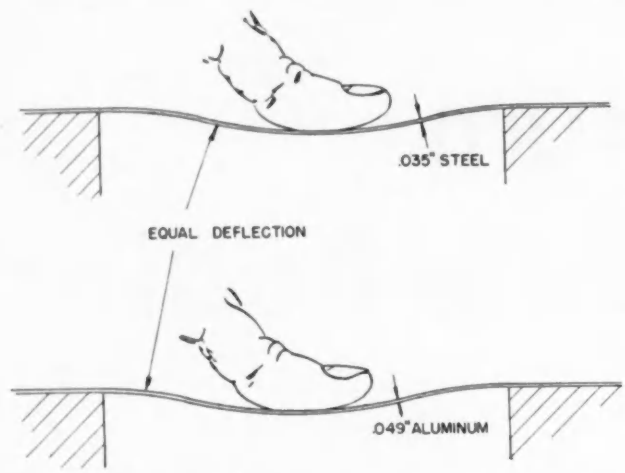

Fig. 1—For equal deflection at one-half the weight, aluminum panel should be 41% thicker than steel

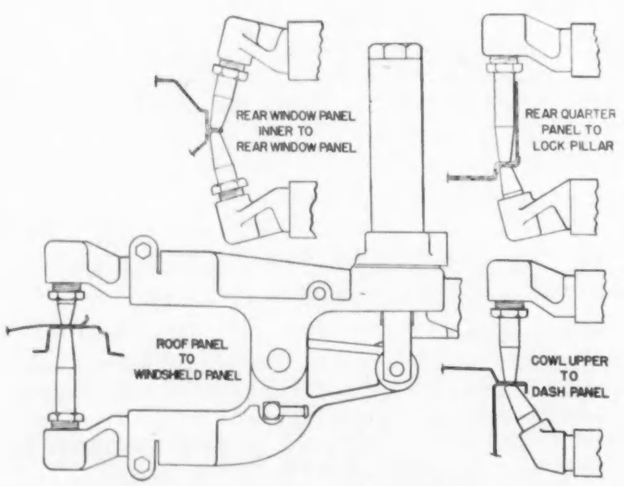

Fig. 2—Variety of jaw extensions used on the portable welding gun

Table 1—Typical Properties of Certain Aluminum Alloys Considered as Basic Materials for the Experimental Body

Alloy and Temper	Tensile Strength, psi	Yield Strength, psi	Elongation, % in 2 in.	Endurance Limit, psi
Class I				
4S-O	26,000	10,000	20	14,000
4S-H32	31,000	22,000	10	14,500
4S-H34	34,000	27,000	9	15,000
Class II				
Alclad 24S-O	26,000	11,000	19	13,000
Alclad 24S-T4	64,000	42,000	19	18,000
61S-O	18,000	8,000	22	9,000
61S-T4	35,000	21,000	22	13,500
61S-T6	45,000	40,000	12	13,500

gained the nod over 61S because the latter required aging in a furnace for an extended period of time.) Here strength was known. . .ability to produce at a commercial cost was not.

It was considered highly desirable for the aluminum body to have a "feel" equal to a customary steel one—that the standard "thumb" test would give the same deflection. Since the modulus of elasticity of aluminum is about one-third that of steel and the moment of inertia of a flat sheet increases as the cube of the thickness, equal stiffness was obtained by making the aluminum panels about 41% thicker than steel. Even with this arrangement, the aluminum was only half the weight of steel. (See Fig. 1.)

This increase in gage may not materially improve the overall stiffness of the entire body. Resistance to local denting, however, varies as the square of the thickness. And Table 2 shows that 0.049 in. 24S-T4 aluminum will have over twice the resistance to local denting as 0.035 in steel, using an optimistic 35,000 psi as the yield strength of the latter. However, with the exception of 24S-T4, the various aluminum alloys listed do not have as high a tensile strength or elongation as steel. Thus, actual tearing or rupture would be less likely to occur with steel.

Welding also presented a number of problems. The aluminum body, which was the subject of this experiment, was very similar in structural design to

Table 2—Comparison of Resistance to Local Denting of Panels of Certain Materials and Gages

Material	Tensile Yield Strength, psi	Gage, in.	Ratio Resistance to Local Denting*
Steel	35,000	0.035	1.0
4S-H32	27,000	0.049	1.5
24S-T4	42,000	0.049	2.4
61S-T4	21,000	0.049	1.2
61S-T6	40,000	0.049	2.2

* Based on thickness$^2 \times$ yield strength.

Table 3—Approximately Twice as Much Current is Needed to Weld Aluminum as Mild Steel

Mild Steel				2S, 3S, 52S, 61S			
Thickness, in.	Tip Force (lb)	Time (cycles)	Current (Amp)	Thickness, in.	Tip Force (lb)	Time (cycles)	Current (Amp)
.021	300	6	6500	.020	350	6	16000
.031	400	8	8000	.032	470	8	18000
.040	500	10	9500	.040	550	8	20000
.050	650	12	10500	.051	640	10	22000
.062	800	14	12000	.064	750	10	24000
.078	1100	17	14000	.081	860	12	28000
.109	1600	23	17500	.128	1150	15	35000
.125	1800	26	19000				

Note: Schedules are for 60 cycle welding machines and cannot be applied to equipment of other electrical design.

conventional steel bodies built by the automobile industry today. Therefore, to attain the most favorable assembly cost comparison, spotwelding was used wherever possible.

Special equipment had to be designed to fit the dimensional requirements and limited accessibility features of the body structure in the following instances:

1. Cowl to:
   (a) windshield panel
   (b) hinge pillar
2. Deck panel to:
   (a) quarter panel
   (b) rear window panel
3. Quarter panel to:
   (a) rear side sill
   (b) rear window panel
   (c) lock pillar
4. Wheelhouse panel to side sills
5. Roof panel to:
   (a) windshield panel
   (b) quarter window panel
   (c) rear window panel
   (d) door header
6. Rocker panel to:
   (a) outer cowl
   (b) quarter panel
   (c) sill panel
   (d) floor panel

Portable welders were used because of the size of parts to be welded. Again this followed present practice in the automobile industry.

The four portable welding guns selected had a variety of adaptors or jaw extensions, which would fit the sections involved. Fig. 2 shows one of these guns, with various jaw extensions, and some of the sections to be welded.

Alloys welded by the portable guns were 4S, 52S, and 61S. The lightest combination was a piece of 0.040-4S-H32 to a piece of 0.051-4S-0. And the heaviest was 0.064-4S-H32 to 0.072-61S-T4.

Power requirements for welding aluminum alloys are considerably greater than for mild steel. As shown in Table 3, approximately twice as much current is needed. These higher current requirements necessitated use of considerably larger welding equipment than would be required for mild steel.

Another important welding problem was the great affinity of copper alloy welding tips for aluminum. Amount of this "tip pick-up" is governed by the cleanliness of the aluminum sheet, welding force used, and the current density at the beginning of the weld.

However, it has been found that the extremely small area of the welding tip, which contacts the sheet before current starts to flow, results in an extremely high current density at the beginning of the weld. And a device has been developed which permits starting a weld at lower current and, as the tip imbeds itself into the work—increasing the contact area, the current is automatically increased to the final value required to make the weld. This "Slope Control" device has resulted in many more spot welds before point cleaning is necessary.

Equipment finally selected to do the job, at the least expense, was a single phase, 250 KVA portable welder, with a synchronous timer incorporating a phase shift heat control and slope control. Fig. 3 shows the welder and control. The welder was equipped with two air valves. One was for applying welding pressure to the gun, while the other was used to apply a light pressure for tip dressing. The booster had an 8 in. diameter air piston and a 1 in. diameter oil piston.

Past experience in spotwelding aluminum alloys indicated some points to be considered in an assembly of this type. To obtain optimum results, the structure was designed so that the weld joints were in shear. And considerable care was given to provide sufficient access and room for the rather bulky spotwelding equipment.

While it is possible to spotweld upon the very edge of a steel sheet, to do so on aluminum would cause expulsion of metal and result in a weld of unsatisfactory strength. Flanges of adequate width were provided to overcome this problem.

Areas inaccessible to the spotwelder were joined by riveting. Torch welding was not used because of the effect of heat, which tends to soften and reduce the inherent strength of the aluminum alloy.

Study of the structure of a typical steel body indicated that the same general pattern of construction would result in an efficient aluminum structure. The panels were so subdivided as to permit forming of parts, bearing in mind the economy resulting from keeping these subdivisions to a minimum. For example, the cowl, windshield roof, and back windows were made in four pieces, whereas in steel these would be formed in a unit. See Figs. 4 and 5. Where necessary to have an exterior panel joint, it was hidden by a molding or placed where it would not distract from the general appearance of the finished body.

It was important that the aluminum body be comparable in rigidity and strength to one of steel. But strength data were not available for a similar

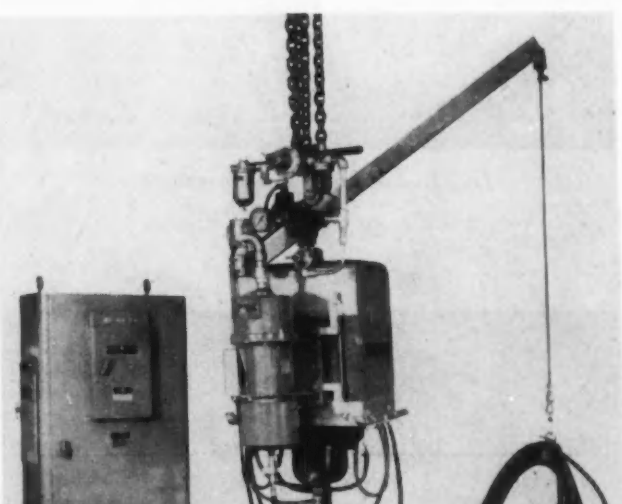

Fig. 3—Welding and control equipment selected for the ticklish job of welding aluminum

Stages in Final Assembly of Experimental Aluminum Body

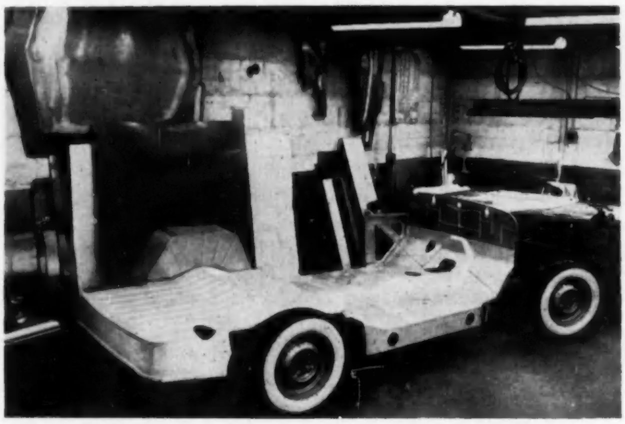

Fig. 1—Top view of aluminum under-body assembly mounted on standard steel chassis

Fig. 2—Assembly accomplished on temporary wooden jigs, using clamping devices for further support

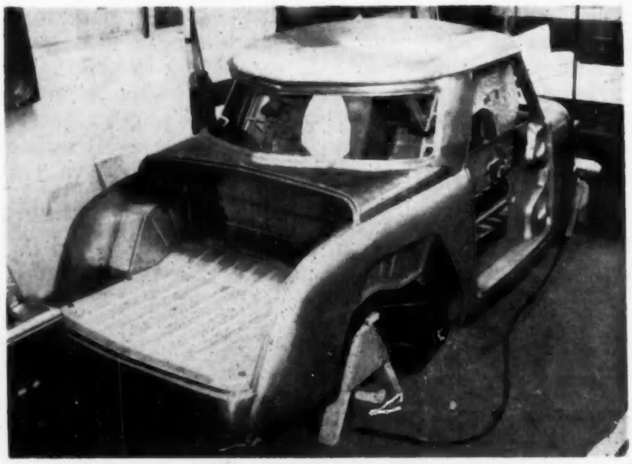

Fig. 3—Body assembly in progress

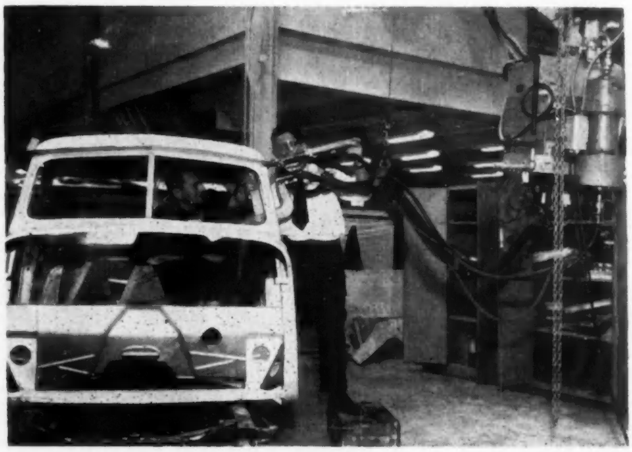

Fig. 4—Portable welder in operation

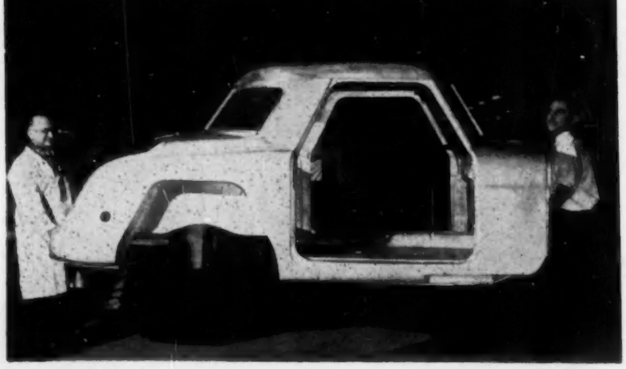

Fig. 5—Body is approximately one-half as heavy as comparable steel one

Fig. 6—Finished car exhibited better roadability and improved resistance to corrosion

steel body from which to calculate the sizes of the various framing members. In general, the cross-section of the aluminum body components was selected to duplicate the rigidity and strength of a conventional steel body. For this reason, most of the box sections of the body were made somewhat larger than those of a comparable steel body. See Fig. 6.

The choice of sheet gages was influenced by function, sturdiness, and cost. Main floor, reinforcing channels, hold-down brackets, cowl and quarter lining panels were made of 0.064 in. thick sheet. Outer body, door, and trunk lid panels of 0.049 in. sheet were selected for reasons of sturdiness. The door framing, consisting of the hinge and lock pillars, was made of 0.072 in. thick sheet stock. Door headers were made of 0.064 in sheet. Trunk lid and other liner panels of 0.040 in. stock proved to be adequately rigid.

This selection of sheet gages was somewhat on the conservative side in order to insure satisfactory performance of these first bodies. Further reduction in stock sizes may be feasible as the result of experience. The completed units appeared to be quite sturdy and to have the equivalent stiffness and rigidity of a comparable steel body. Road testing is underway to fully evaluate serviceability of these bodies.

Parts for the bodies were formed in drop hammer dies. Plaster casts, taken from the full scale mockup, served as patterns for the Kirksite die mold. After grinding and polishing the die, a lead punch was molded over it. Upon completion of fabrication of the required number of parts, the dies were remelted and other dies made.

For quantity production, experience has shown that aluminum body panels and parts can be readily manufactured in conventional iron or steel forming dies, similar to those used for steel panels. Die material—cast iron, alloy cast iron and carbon steels—should not be porous and should be polished so as not to scratch the material while forming.

No serious difficulty was encountered during the forming of parts. Material was allowed to flow freely with blank holder pressure just enough to prevent wrinkles from starting. Forming of compound curves was successfully accomplished by the displacement of material rather than stretching or drawing. Suitable lubricants were employed to encourage free flow of the material.

Detail parts were cleaned in preparation for spot-welding. The cleaning process consisted of degreasing bath, acid etch, hot water rinse and air drying. (Acid etch prepared the surface for maximum adhesion of the paint primers applied during a later operation.)

Parts that had been cleaned were next placed into assembly fixtures. Assembly of the bodies was accomplished on temporary wooden jigs, using clamping devices for additional support. Assemblies consisted of the usual units—the underbody, front end, back end and, finally, the complete body assembly. The various parts were joined with pedestal or portable welding machines.

As a matter of convenience and expedience, standard hardware items such as door hinges, locks,

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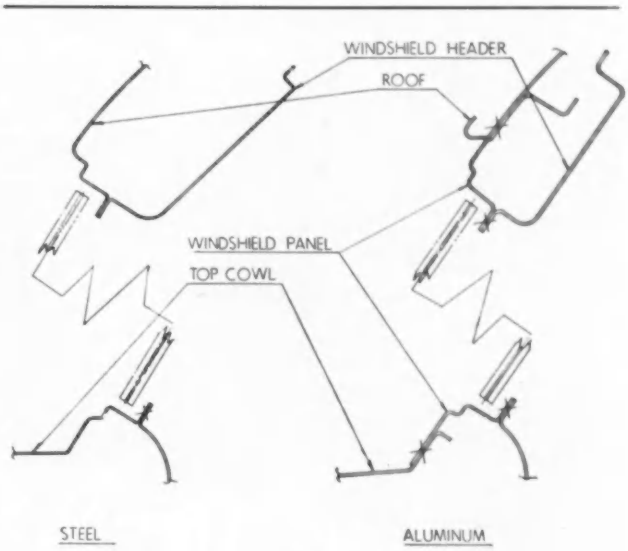


Fig. 4—Cowl, windshield, and roof sections

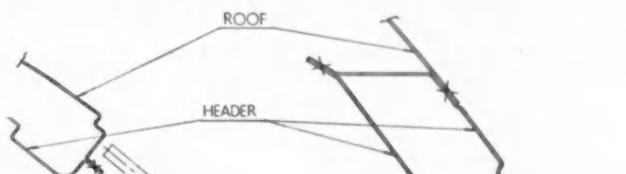


Fig. 5—Roof, back window, and upper deck sections

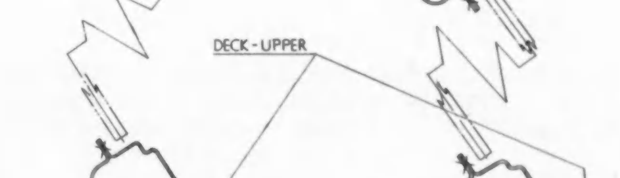
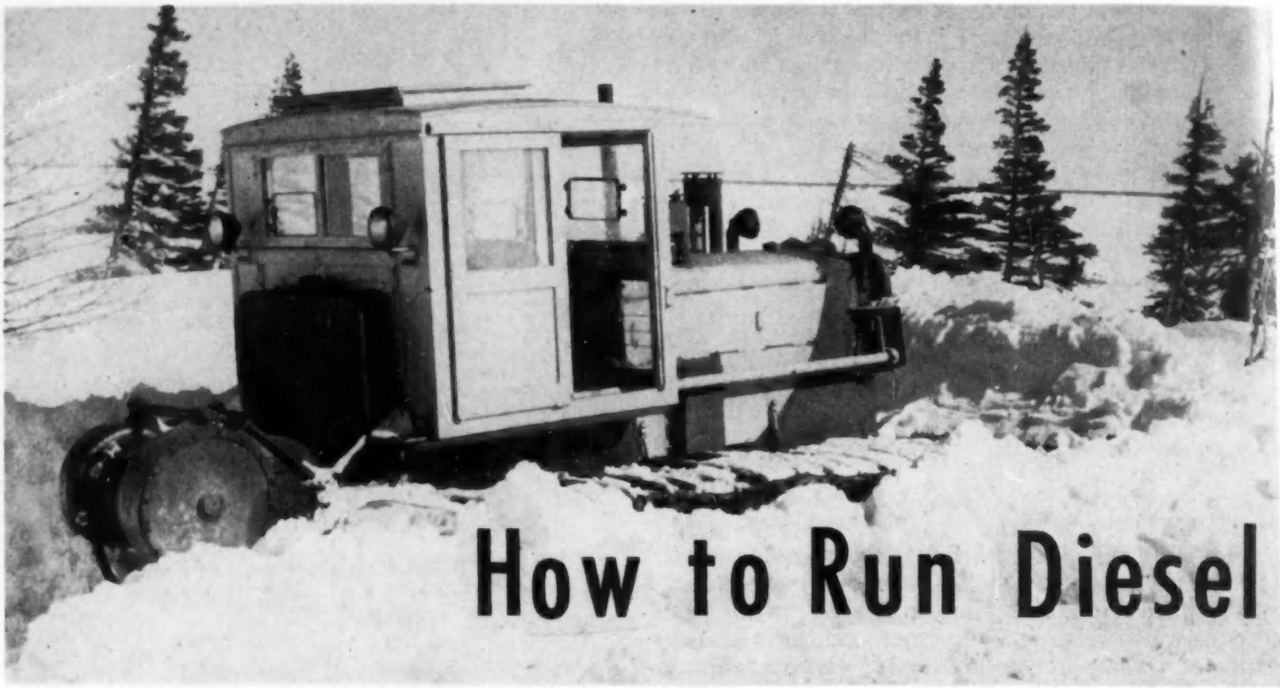


Fig. 6—Aluminum box sections were made somewhat larger to duplicate rigidity and strength of conventional steel body



How to Run Diesel

THE problems of starting and operating diesel engines of small and medium size at low temperatures (down to − 65 F) can be classified as follows:

1. Cranking

It is necessary that power be available to turn the engine over at a minimum speed of about one-tenth that reached during normal operation. This is an especially difficult problem since (a) at high discharge rates the energy available from standard lead-acid cranking batteries is greatly reduced at temperatures in the neighborhood of − 60 F, and (b) internal-combustion starting motors are very difficult to turn over at such low temperatures.

2. Ignition

Ignition must take place satisfactorily in the cylinders with very low inlet air temperatures. Ignition is influenced not only by inlet air temperature but by engine cranking speed, compression ratio, size and design of the individual cylinders, atomization and mixing of the fuel with air, use of fuel additives and starting aids such as diethyl ether, and characteristics of the fuel, such as its composition, cetane number, and volatility.

3. Fuels

The fuel must pour at temperatures encountered, must be satisfactory from the standpoint of cetane number, and must have a flash point sufficiently high not to be a fire hazard. Steps must also be taken to avoid clogging of the fuel lines and fuel filters with wax, which may precipitate below the cloud point temperature or with ice crystals formed from water in the fuel.

4. Lubrication

A crankcase lubricant satisfactory for an engine required to make cold starts must have a viscosity at very low temperatures in the range of 10,000-40,000 SUS so that it can be pumped and the engine turned over without excessive expenditure of power or wear on the bearings. In addition, the lubricant must meet the usual high-temperature requirements, such as a high enough viscosity at engine-operating temperatures (160 to 180 F optimum) to avoid excessive engine wear and oil loss in the cylinders, a sufficiently high flash and fire point not to be a fire hazard, and high oxidation stability.

5. Coolants

Since most diesel engines in this country are liquid-cooled, many of the same problems encountered in lubrication are also faced in cooling. The coolant must act as an antifreeze at very low temperatures and must remain a liquid with a viscosity low enough to allow pumping at this low temperature. In addition, it must possess a relatively low vapor pressure and high thermal stability at the higher operating temperatures. It must also be noncorrosive, present no undue fire hazard, and should have a high heat capacity.

6. Engine design and materials of construction

Materials used in the engine and its accessories must be carefully selected on the basis of their low-

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Engines in Cold Weather

temperature properties. Flexible hoses, gaskets, and insulation must not become brittle or develop cracks at low temperatures and yet must not flow or deteriorate rapidly at more normal temperatures.

It can be seen that many of the low-temperature problems involve the selection or discovery of materials and substances that are not only suitable for low-temperature use, but that have the proper characteristics at the normal operating temperatures of the engine. This second requirement adds to the complexity of the problem.

Table 1 summarizes the low-temperature problems encountered, the various remedies attempted, and the best solutions that have been achieved up to the present time. Various aspects of the low-temperature starting and operating problems of diesels will now be discussed in some detail.

Cranking

There are several sources of power that can, with proper modification, be used to crank diesel engines at subzero temperatures:

Battery-powered starters

It is possible to use an electric starting motor at low temperatures if special batteries are employed. The sintered-plate, nickel-cadmium battery being developed by the Nickel-Cadmium Battery Corp. is stll in the experimental stage but holds promise of being especially well adapted to low-temperature operation. It has long life, high efficiency at high discharge rates, and the ability to be charged and discharged at temperatures at least as low as - 40 F. The alkaline electrolyte is contained in an iron battery case, which adds to the durability and ease of heating. However, this battery occupies a good deal of space and costs from five to ten times as much as the ordinary lead-acid battery. Its production in wartime might also be limited because of the strategic nature of cadmium metal and its limited supply.

Special lead-acid batteries also have promise of successful operation at low temperature. Delco-Remy has an experimental battery of this type which has a fairly good discharge rate down to - 65 F. It cannot be charged in a reasonable time at this temperature, but it can be charged at temperatures between - 40 and 0 F. For lead-acid storage batteries to be used successfully as a source of cranking power below - 60 F, the battery will probably have to be increased in volume by two to four times, and the starting motor will also have to be enlarged considerably.

Hydraulic starters

This type of starter depends for a source of power upon the expansion of high-pressure air contained inside a bladder. A liquid is first pumped into an accumulator tank surrounding the bladder, thus shrinking the bladder and compressing the air inside. During discharge, the air expands from 3000 psi to about 750 psi, forcing the liquid out of the accumulator tank and through the hydraulic starting motor. The hydraulic fluid upon discharge from the starting motor flows into a storage tank and is returned during recharge by either an engine-driven or a hand-operated pump.

Hydraulic starters can deliver sufficient power to

start diesel engines at very low temperatures. Their two advantages over batteries are: (1) they can deliver their stored energy at high rates without appreciable loss in efficiency, and (2) they can store about the same amount of energy at low temperatures as at normal temperatures. If such minor difficulties as cracking of the bladder and the increased viscosity of the hydraulic fluid at low temperatures can be overcome, the hydraulic starting system has considerable promise for use at low temperatures.

Pneumatic starters

These starters, developed by Ingersoll-Rand and others, employ air as a working fluid. The air is used to operate a starting motor or to turn the diesel engine over directly by introducing air into the cylinders through special valves. None of the present designs will deliver the required amounts of power for a sufficiently long time to ensure the starting of a medium-sized diesel engine, and the design of an efficient air-operated cranking motor that will work at low rpm on a variable air pressure has not yet been worked out. Thus, a pneumatic cranking system for low-temperature use cannot at present be practicably employed.

Fuel-burning starters

Another possibility that has been investigated as a source of power for starting diesel engines at low temperatures is the use of a fuel-burning starting motor. Small gasoline-burning cranking motors now in use have the advantages that they will deliver an almost unlimited amount of energy for cranking at their rated horsepower and that the heat from the coolant and exhaust gases of the starting motor can be used to warm up the diesel engine before it is cranked.

However, these motors also have some disadvantages. Present motors require the transportation and storage of gasoline, an additional fuel which presents a considerably worse fire hazard than diesel fuel. Also the starting motor itself must be started, and it may be necessary to solve the problems of starting and operation for the small motor, although most of these small starting motors can be hand-cranked or started with bat-

Table 1—Summary of Low-Temperature Problems and Remedies Employed

	Cranking	Ignition	Fuels	Lubrication	Coolants	Engine Design
Problems	1. Electric starters drain batteries excessively 2. Gasoline starters themselves are hard to start and require different fuel	1. Most fuels not ignitable at low temperatures	1. Most commercial fuels are solid at -45 F	1. Pour points of most lubricants are about 0 F 2. Viscosity index of most oils is too low	1. Water-base coolants do not have low enough freezing points 2. The alcohols are too volatile or lack necessary stability	1. Fuel pump and oil pump are underdesigned 2. No way to heat fuel & lubricants readily 3. Electrical insulation & rubber crack at low temperature
Remedies	1. Use special battery 2. Use hydraulic starter 3. Use pneumatic starter 4. Use special gasoline starter 5. Use diesel-powered starter which can be cranked 6. Use cartridge starter	1. Burn fuel in air inlet to heat air 2. Inject diethyl ether into air manifold 3. Use gasoline and spark ignition initially 4. Use special fuel-air mixer and spark	1. Use pour-point depressants 2. Use kerosene fractions 3. Dewax commercial diesel fuel	1. Use dewaxed or low-paraffin stocks 2. Use pour-point depressants 3. Use synthetic lubricants 4. Use special unlubricated surfaces	1. Use lubricant-type liquid as coolant 2. Use ethylene glycol-water or butyl alcohol-water mixtures	1. Use dry oil sump to heat lubricant quickly 2. Use synthetic rubber V-belts 3. Use engine designed specifically for low-temperature work
Best Solutions	1. Use special lead-acid battery 2. Use sintered-plate nickel-cadmium battery down to -40 F 3. Use gasoline starting motor that can be hand-cranked 4. Use hydraulic starters	1. Use diethyl ether	1. Use premium diesel fuels down to -40 F 2. Use kerosene stocks or dewax stocks to -65 F	1. Use synthetic lubricants	1. Use one of synthetic lubricants as coolant	1. Use engine designed specifically for low-temperature work

teries or starting cartridges.

A starting motor that burns diesel fuel would be a very desirable development. The problems of cranking and lubricating this engine could probably be overcome. The combustion problem in such a low-temperature starting motor might be solved by use of the so-called Texaco combustion process, in which the air rotates inside the cylinder and a relatively stable flame zone is established. Diesel-type fuel injection is combined with spark ignition in such a way that almost any hydrocarbon fuel can be used. Use of this cycle, combined with a high compression ratio, a high cranking speed, and perhaps ether injection into the manifold should make it possible to start such a small motor at temperatures below - 60 F.

Cartridge-type starters

The use of cartridge starters, in which the motor is turned over by explosion of gases held in a small cartridge, does not appear attractive for cranking larger diesel engines. The inertia of heavy engines is so great that a large charge would be necessary to achieve the required cranking speed in one stroke. Also, the force required to accomplish this high engine acceleration would overload and reduce the life of the diesel-engine bearings.

To summarize, it appears that the best presently available means of starting diesel engines at low temperatures are hydraulic starters, gasoline-burning starting motors, and battery-powered starters employing special storage batteries. None of these methods is completely satisfactory, however, and it is to be hoped that further attention will be given to the development of a diesel-type cranking motor that could preferably be started by hand.

Ignition

At ambient temperatures of 40 F or above, air from the outside atmosphere can be adiabatically compressed in the diesel-engine cylinder to a sufficiently high temperature for ignition to occur if the diesel fuel used has a cetane number of 40. At somewhat lower temperatures, starting is still possible if higher cetane fuels are used, but at very low temperatures it is impossible to get sufficiently high cetane fuels. Hence other expedients have had to be adopted.

Auxiliary heat addition

One method involves the application of heat to the air inlet manifold by burning a limited amount of fuel (either gasoline or diesel fuel) in the air manifold. The fuel is injected into the manifold under moderate pressure to get good atomization and is ignited with the aid of a torch or a spark plug. The hot combustion products, mixed with excess air, are then permitted to enter the cylinders.

Injection of chemicals

Another good method is to inject fluids that will ignite at low temperatures into the air intake manifold. Many substances of this type have been investigated, and diethyl ether is the best so far discovered. Injection of ether is remarkably simple and has been widely adopted by commercial operators in the North and Northwest. It has given successful starts in cold engines at ambient temperatures of - 55 F in a matter of seconds. The ether is now available in small, steel, pressurized capsules so that the fire hazard is practically eliminated.

Spark ignition is often employed along with the injection of chemicals. International Harvester uses spark ignition, injection of gasoline into the air manifold, a lower compression ratio, and an otto cycle for starting its engines. It should also be possible to obtain good ignition by the injection of gasoline into the air manifold through an atomizer attached to a pressurized capsule. The capsule method would make it possible to use a gasoline of a high Reid vapor pressure, or even pressurized gaseous fuels. The injection of such fuels into the air manifold has not yet been subjected to experiment.

Special combustion methods

Another approach to the problem of getting diesel engines started at low temperatures has been proposed by the Texas Co., which advocates the use of the already-mentioned Texaco combustion process. Its success depends upon creating a swirling motion in the air under compression in the cylinder, followed by injection of the fuel tangentially to the cylinder wall past an electric ignition spark. A wide range of fuels, including both high-octane gasoline and diesel fuel, has been burned successfully. The operating principle of the engine appears attractive for use at low ambient temperatures, but no low-temperature tests have been made.

Summarizing, the use of diethyl ether appears at present to be the best way to insure ignition in diesel engines at low temperatures. When employed in pressurized capsules it is quite safe to use, and it involves no extra equipment such as spark plugs to aid ignition.

Fuels

The desirable qualities of a good diesel fuel for low-temperature use are a high cetane number and a low pour point. The following methods are available for lowering the pour point without sacrificing too much in the cetane number:

Use of premium fuels

One commercial petroleum diesel fuel, Standard of California stove oil, has a pour point below - 65 F. This fuel, however, is from a limited West Coast stock. Light kerosene fuels have pour points of - 65 F or below. These are also premium fuels. As long as only a limited fuel supply is required for arctic operations, such kerosene fractions having a flash point of not less than 150 F can be employed. If a larger per cent of the crude oil must be utilized, it will probably be necessary to permit a more realistic pour point of about - 40 F, or to take further steps such as dewaxing or the addition of pour-point depressants.

Use of dewaxed fuels

The pour point of fuels can be lowered by removing some of the higher-boiling fractions through a solvent extraction process or a low-temperature

dewaxing operation. There is a sacrifice in cetane number in using these dewaxed diesel fuels, but the lowering of the cetane number is a condition which must now be faced, even in service at more normal temperatures, because of the oil industry's tendency to substitute cracked stocks for straight-run paraffins. A slight lowering of the cetane number will not materially affect engine efficiency or smoothness of operation. Shell Oil Co. has delivered diesel fuels with pour points from - 80 F to below - 110 F for testing by Army Ordnance. These fuels were prepared by a pilot-plant dewaxing process that could be adapted to large-scale operations.

Use of additives

The use of additives to lower the pour point, although having some merit, does not generally lower the cloud point a proportionate amount. Since the presence of wax crystals below the cloud point tends to clog the filter and injection systems, it is desirable to use fuels at temperatures above their cloud points. Nevertheless, pour-point depressants may at times be more economical than further dewaxing or use of lighter fuels.

It may be concluded that there is no one completely satisfactory answer to the low-temperature fuel problem, but that, by a combination of proper selection of base stocks, use of dewaxing, and addition of pour-point depressants, a suitable fuel can be prepared. It will however, be availble only at a higher cost and in more limited quantities than present common diesel fuels.

Lubrication

At temperatures down to - 20 F petroleum lubricants now on the market can meet the requirements. The problem becomes much more difficult at temperatures down to - 65 F. Even with the use of viscosity index improvers and pour-point depressants, it is doubtful if lubricants from petroleum can be made available in the required quantities. Low-temperature solvent dewaxing of present commercial lubricating oils should result in satisfactory pour points, although the yield of final product may be low. However, there are three other aproaches that can be used:

Synthetic lubricants

If it were not for the price and availability, the use of synthetic lubricants or blends of these with petroleum lubricants would offer the best solution to low-temperature lubrication problems, as these lubricants have outstanding properties. Even without the addition of additives, di-ester synthetics such as di (2-ethylhexyl) adipate (Plexol 202), made by Rohm and Haas, and diisoamyl sebacate are considerably better than petroleum lubricants. They have lower pour points (- 80 F), higher viscosity indexes, lower decomposition rates, and leave the engine in better condition.

Synthetic polyethers such as the Ucon oils made by Carbide and Carbon Chemicals Corp. have also been developed which parallel the diesters in properties, with the exception that their pour point is in the neighborhood of - 40 F. However, both types of synthetic lubricants can be considerably improved through the addition of pour-point depressants, viscosity index improvers, antioxidants, rust inhibitors, and lubricity additives. Their greatest drawback is their price ($2.50 to $4 per gal).

Although the silicone oils have many desirable properties, they do not lubricate iron and steel surfaces effectively and are thus unsuitable for most lubricant applications.

Dilution

Dilution has the disadvantages for use with diesel engines that it requires the carrying of another liquid, it presents a fire hazard, it is difficult to control, and it may have detrimental effects upon the properties of the lubricating oil.

It seems that further development work on this method would be highly profitable. By using a nonflammable diluent, such as a fluorocarbon, and a small condenser to recover the vapors as they exhaust through the crankcase vent, it might be possible to work out a carefully controlled process that would be easy to employ.

Dry sliding surfaces

A novel approach to the problem of lubrication is to develop sliding surfaces that require no lubrication. Engineering Research Associates, Inc., has found that two nickel oxide surfaces in sliding contact operate with an extremely low coefficient of friction and can function for long periods of time without appreciable wear. The data on the bearings are scanty, however, and no low-temperature tests have yet been run.

Grease is used in diesel engines only to lubricate the fan housing and as packing for the water pump. There is not a serious grease problem at low temperatures, as satisfactory greases are available. The best ones are based on diesters for the liquid phase and lithium, sodium, calcium, or aluminum soaps for the solid phase.

To summarize, the most feasible low-temperature lubricants at present appear to be the synthetic polyethers and diesters, although it is entirely possible that further work on the dilution or the dry-surface method may show that one of these is superior to the use of the synthetic lubricants, particularly from the cost and availability standpoints.

Coolants

For operation down to - 20 F, there is no serious coolant problem, and ethylene glycol-water mixtures serve quite adequately. Butyl alcohol has been added to this mixture to lower the freezing point to -70 F, but it boils out rather easily. For low-temperature use, it seems reasonable that a liquid which is a good lubricant should also be usable as a coolant, provided that it does not attack the rubber hoses of the cooling system. At temperatures below - 20 F, the diester oils already mentioned as lubricants appear to be best from both the price and performance points of view. They have a wide liquid range and are sufficiently stable for use at normal engine operating temperatures. If such an oil is used as a coolant, it will be necessary to use hoses, gaskets, and sealing compounds that will not be acted upon by the oil. This, how-

ever, should not present an insurmountable problem.

If price were no object, the silicone oils would probably be the best substances for use as coolants. These materials have unusually flat viscosity versus temperature curves, pour points as low as -130 F, and high flash points. They also have low vapor pressures and good stability at the higher engine temperatures. However, these oils are priced at about $40 per gal.

A few other substances, such as propylene and hexylene glycol, have been investigated but appear to be no better than ethylene glycol. Kerosene has been recommended as a good coolant, but it might present a serious fire hazard if the engine becomes overheated.

The problem of coolants does not appear to be as serious as some of the other difficulties inherent in the low-temperature starting and operation of diesel engines, since the quantities to be used are not as great as those of lubricants and fuels, and the substances available have properties quite adequate for the service.

Engine Design and Materials of Construction

Up to the present time no manufacturer of diesel engines has designed a diesel engine from the ground up specifically for low-temperature operation. The cost of such a development program would probably be prohibitive, and the most we can expect in the future is for the most critical components of the engine to be improved so that reliable operation down to below - 60 F is possible. A great deal of work under carefully controlled low-temperature conditions must be done to determine the effects of various design variables on the starting and operation of diesels. The effect of compression ratio, combustion-chamber design, cranking speed, fuel/air ratio, fuel atomization, and ether injection in the manifold on starting should be carefully considered.

The following specific engine components are well worth additional investigation:

The fuel system

Fuel pumps require improvement to make them capable of handling more viscous fuels at the lower temperatures. Consideration should be given to overhaul of the fuel injection system with the objectives of: (a) improving fuel atomization at low cranking speeds and high fuel viscosities, (b) incorporating a priming device that will allow injection of additional fuel during cranking, and (c) allowing variable timing of the fuel injection.

The lubricating system

The lubricating oil pumps should also be redesigned so that oils varying in viscosity over a wide range (up to about 40,000 SUS at the lower temperatures and down to 30 SUS at the higher temperatures) can be successfully handled.

Another improvement that might be adapted to diesel-engine lubrication is the use of a dry oil sump, in which most of the oil is stored in a separate tank instead of in the crankcase. This makes it possible to avoid preheating all of the oil at the time of starting the engine, and it also permits the oil in the tank to be separately heated. The dilution of crankcase oil with a volatile solvent would also be easier if a dry oil sump were used. Finally, a method might be worked out whereby the oil could be circulated through a preheater before cranking.

The cooling system

Perhaps one of the most important changes that must be made to assure satisfactory operation at low temperatures is to redesign the cooling system on the principle that the coolant should not only be circulated to remove heat from the engine hot spots but must also deliver heat to regions where it is needed. This requires that coolant be circulated through the crankcase, around the battery, through the transmission, and to other points where heat might be required. Thermostats would be needed to give sufficient control so that overheating at these points does not occur. So that this heat can be used most effectively, insulation of many parts of the engine and its auxiliaries is also necessary.

Miscellaneous considerations

In designing an engine that is to be started and operated at very low temperatures, the effect of this low temperature on clearances must be taken into account, and consideration must be given to design changes required to reduce engine wear due to condensation of moisture and combustion products. Designs must also be modified to accommodate any auxiliary heating equipment, starting devices, and apparatus for the injection of starting fluids.

Controls on the engine and auxiliary equipment should be modified to allow their manipulation by personnel wearing heavy gloves. Provisions should be made for adequate instrumentation for low-temperature starting and operation.

Except for problems of fan belts, flexible hoses, and electrical insulation, no serious difficulties associated with diesel-engine materials of construction have arisen in arctic service. At present it appears that a new polymer of butadiene and styrene referred to as "90:10" will be satisfactory for fan belts and flexible hose for use at very low temperatures, but further work is necessary to get a completely satisfactory electrical insulation and oil-resistant rubber.

Use of Stand-By Heater

If, when an engine is shut down during cold weather, enough heat could be supplied to compensate for heat losses to the surroundings, the temperature of the engine and its auxiliaries could be maintained at a high level and the engine could be started immediately, even after long periods of idleness.

Although stand-by heaters do not appear as attractive as quick-start heaters for use on diesel equipment required to operate in the Arctic, it appears that reliable stand-by heating systems will continue to have many important applications. Work on the improvement of these systems might well be continued with emphasis on increasing the

reliability, improving the temperature control at the critical points to be heated, and developing heaters that burn diesel fuel.

A careful investigation is needed of the possibility of building into stand-by heaters a thermopile system for power generation. There is some indication that such an installation, if properly designed, could generate enough power for the forced-draft fan motor.

Rapid-Heat Addition Prior to Starting

Perhaps the most desirable arrangement for warming the engine prior to starting would be to apply heat very rapidly by means of a quick-start coolant heating system so that, even from an initial temperature of -65 F, the engine could be warmed to starting temperature in a about five minutes.

A quick-start heater of optimum design should: (1) be easy to start, (2) be reliable, (3) be compactly designed, (4) transfer a high percentage of heat liberated to the coolant, (5) utilize combustion gases to heat the air intake manifold and perhaps the oil pan, and (6) operate satisfactorily on diesel fuel.

Aside from the heater itself, the major problems associated with design of such a system are those of heat transfer. It is necessary that heat from the coolant or the combustion gases be added at very high rates to such vital points as the battery, the crankcase, and the air-intake manifold. Rapid-heat addition to the battery should receive very careful attention. In order to obtain a sufficiently high rate of heat transfer it will very likely be necessary to employ an insulated battery case of special design through which hot coolant can be circulated. Thermostat controls with a coolant bypass might also be a desirable feature to avoid battery overheating. Coolant coils installed in the crankcase will aid in allowing rapid-heat addition to the lubricating oils, and it will be necessary to heat the transmission of some engines in a similar manner.

Circulation of the lubricating oil is a method of carrying heat to the bearings, to the pistons, and to other portions of the engine where the coolant itself does not circulate appears attractive as a method of decreasing the time required for warming the engine. A separate coil for heating the lubricating oil could be mounted in the combustion chamber and a battery-driven oil pump would maintain circulation.

From a practical viewpoint it appears most desirable, at least for the immediate future, that auxiliary heat be used to warm diesel engines at temperatures below about -20 F, since below this temperature problems of cranking, ignition, and fuels become increasingly difficult to overcome. This temperature could perhaps be lowered somewhat if necessary to, say -30 F, but from the point of view of the Navy -20 F is a convenient choice, since it is also the lowest temperature at which diesel equipment in navigable ice areas must start and operate.

Since quick-start heating systems offer the most attractive means of warming the engine and auxiliaries, it appears that a high priority should be given to the development of such systems capable of warming engines from -65 F to starting temperature (perhaps -20 F) in about five minutes.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Alloy Aluminum for Automobile Bodies

Continued from Page 39

handles, and window regulators were used.

The welded and assembled body was then ready for metal finishing. Joints and surfaces requiring attention were filled with one of the approved plastic body solders. Since these materials are rather quick drying, it was possible to file and sand the filler without delay, producing the desired smooth surface necessary for a fine finish.

Primer coats of pyroxilin, zinc chromate, or other quick drying compositions were considered suitable. Two coats of primer were applied to the under-body. Finishing coats of enamel, synthetic enamel, or lacquer were used with satisfactory results.

The completed coupe body contained 287 lb of aluminum. With the addition of such steel parts as hinges, window regulators, locks, and handles, the body-in-white weighed 312 lb. A similar all-steel body would weigh 600 lb.

Complete car curb weight was 2,406 lb, which included water, oil, full 15 gal gas tank, over-drive, spare tire and wheel, front and rear bumpers, and bumper guards. A conventional car with all-steel body would weigh 2,700 lb. Hence, a weight reduction of 11% was obtained by using this all-aluminum body. By extending the adoption of aluminum to the various chassis components, wherever practical, it is estimated that an additional 200 lb could be saved.

The lighter body lowered the center of gravity of the completed vehicle quite noticeably, resulting in reduced side-sway and better roadability. Improved corrosive-resistant properties of the aluminum body under the attack of the elements further illustrates the superiority of this material.

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Lockheed Constitution Systems Development

EXCERPTS FROM PAPER BY

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and

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• Paper, "Lockheed Constitution Development Story," was presented at the SAE Annual Meeting, Detroit, Jan. 9, 1951.

SINCE the size and complexity of the Constitution were unusual, and since the expense and risk of flight testing such a large airplane with relatively unproved components were not reasonable a complete system of development program was instituted to ensure before flight that the major airplane operating units would function satisfactorily. This type of preflight system checkout had been pioneered in the development of the Lockheed Constellation and its value more than affirmed.

The complete hydraulic system was mocked-up for full-scale operation testing. This mockup included all of the hydraulic systems of the airplane and reproduced as completely as possible all details of the landing gears, wing flaps, brakes, and control boosters in such a manner that all parts were installed in their correct operating positions with respect to the airplane.

In a similar fashion, the complete electrical system designed for the airplane was mocked-up so that it could be controlled from an accurately reproduced flight engineer's station. Both hydraulic and electrical mockups were so arranged as to permit the producing of failures or faults in order to determine the exact procedures and effectiveness of handling such failures while in flight. Air loads were simulated in the flight control hydraulic mockup so that in addition to flight engineer's and mechanic's training, the pilots selected to fly the airplane could be checked out on the complete functioning of the flight control equipment. Figs. 1 and 2 show the hydraulic and electrical mockups.

Electrical System

A load analysis of all the requirements that could simultaneously be placed on the ship's electrical system revealed an amazing power requirement; so much so, that the total electrical potential available from the generating equipment on the airplane is in excess of that required by 20 average homes at peak load.

In an airplane the size of the Constitution, the length of wiring running throughout the ship is in excess of 25 miles. This factor alone pointed toward a high-voltage system as a means of keeping the weight within reason. Comparatively little experi-

THE development of the Lockheed Constitution presented many new problems in design and construction because of its large size and original conception as a combination cargo- and passenger-carrying airplane.

The authors show here how many of these problems were solved for the various systems of the airplane—the hydraulic, the electrical, and the like.

In the complete paper the authors cover all phases of the development story, including design, aerodynamic, and powerplant developments, basic structural design, production design, maintenance provisions, and flight development.

It is particularly to be noted, the authors point out, that the very size of the airplane permitted the designers to incorporate many unique ideas that measurably improved the serviceability of the airplane and reduced its operating costs.

ence on high voltage in aircraft was available, to say nothing of the almost complete lack of aircraft-type motors, and so on, suitable for the high-voltage system.

The Air Force had already committed itself to the use of a 208-v, 3-phase, 400-cycle a-c system on a large airplane, and it was felt to be advisable to follow along in the same pattern. The General Electric Co. was anxious to enter into the development of electrical systems in large aircraft, and a working agreement was drawn up between Lockheed and General Electric to carry on jointly the work necessary to develop a suitable system.

The very heart of a successful a-c electrical system is, of course, a constant-speed device for driving the alternators. In connection with the Air Force project, there were several manufacturers under contract developing such a unit. While there were many problems involved in the working details of a constant-speed drive, they all seemed to be readily capable of solution. All of the units under development were based upon the same general philosophy of a hydraulic pump and motor arrangement with either pump or motor flow being regulated so as to result in constant output speed throughout the entire engine speed range.

With all of the factors apparently under control, the airplane electrical system design went forward. Very attractive weight savings were recorded when compared with any of the usual low-voltage systems formerly used. A basic 3-wire system was used as required by the 3-phase type of power, and all power equipment employing motors was considerably lightened by taking advantage of the higher speeds possible with the 400-cycle power. Before the development and testing work on the constant-speed drives had progressed very far, it became apparent that they were all in serious trouble and were not behaving as predicted. Again it seemed possible that the problem could be solved but, to be conservative, we dug into the details of a possible retreat in the event that time did not permit a satisfactory solution to the constant-speed problem.

The constant-speed drive failed to materialize in time for installation in the Constitution, and a change-over to 110-v direct current as basic power was made. It was indeed fortunate that the problems concerned in converting from alternating to direct current had been studied and planned, since the conversion was made with comparatively little effect on the airplane system itself. The first airplane was already completely wired when the decision was made, so it can be easily imagined that there would be considerable delay if the change were extensive. Basically, the solution was to use the three wires already installed for the a-c circuit as a common wire for the d-c system with the airplane structure as a ground. The alternators and motors, of course, had to be replaced, but the wiring itself, which formed the biggest installation problem, was largely unchanged.

Control System

In establishing the basic flight control system to be used in the Constitution, two factors were given equal importance: safety and pilot's control forces. Following the successful experience already established on the Constellation and P-38, we again adopted the basic philosophy of using hydraulic boost. Because the control surfaces were large, and no aerodynamic balance was contemplated, it was immediately apparent that a pilot could not at any time apply sufficient force unaided to the surfaces to control the airplane properly. This is another way of saying that boost was mandatory for all flight conditions. Heretofore, as in the case of the Constellation, the pilot could "shift gears" and manually bring the airplane to a successful landing with his boost system out.

The problem, then, was to build complete safety into the Constitution system even though it was completely dependent upon supplementary power. A single hydraulic system was obviously not the answer and, perhaps, multiple circumstances could develop which might cause two systems to fail simultaneously, so three completely independent systems were selected. "Independent" is used in its strictest sense, in that the three systems are totally separated in all respects from the source of fluid to and including pumps, lines, valves, actuating cylinders, and the like. Furthermore, the location of pumps on the engines was such that any two of the three systems could be completely inoperative, leaving horizontal and either vertical or lateral control for the pilot at all times. As actually determined by flight testing, all four engines could be dead and sufficient power would be supplied by one wind-milling propeller to provide suitable control for landing.

It might seem at this point that all contingencies had been taken into account but, as an added safety feature, it was decided that the trim tabs on all three control surfaces should be electrically actuated. This feature too has been demonstrated in flight by turning off all of the hydraulic systems and flying the airplane on the electric trim tabs alone.

An interesting sidelight on the pilot's control of the electric tabs arose during the mockup review

onferences. The usual wheels or cranks that have caused much controversy as to direction of motion in pilots' compartments had led to rather stringent rules within the Government agencies such as the CAA, Navy, and Air Force. Since these rules were all based on cable-operated systems, they were quite worthless when an electrically operated system was considered. As the result of numerous studies, a very simple system was devised, which closely resembles a miniature control stick. Since four switches could be operated from a single lever to give the normal reactions of lateral and vertical control normally associated with a control stick, there was no problem as to how the stick should move to produce the required trim on the airplane. Fig. 3 shows this tab control as installed on the central control pedestal located between the two pilots.

One extremely important point in connection with the success of a hydraulic booster system is the measured value of the control system friction. The Lockheed boost system retains, as a basic part of the design philosophy, the normal pilot "feel". This is a true value arising out of the arrangement of linkages in the boost system which translates pilot forces into applied forces at the control surface and, conversely, the air loads on the surfaces react directly to the control points in the cockpit. The ability of this reaction to take place and permit surfaces to neutralize when no stick forces are applied is in direct proportion to the value of the control cable friction. High friction would prevent the surfaces from returning to neutral because this would produce the same effect as a positive stick force applied at the controls in the cockpit, tending to hold any surface displaced. The most obvious answer to reducing cable friction forces is to use straight cable runs so that the atendant friction produced by changing direction around pulleys can be eliminated. The deep upper deck floor structure on the Constitution proved invaluable in this regard, as shown in Fig. 4. Perfectly straight cable runs over extremely long distances are made possible by running the control cables through this structure. As shown in Fig. 4, the control system would appear to have been the governing criteria in the airplane configuration, since no airplane component has been permitted to interfere with straight control cable paths. The resulting low friction values have never before been attained, even in small twin-engine transports.

Hydraulic System

As already stated in connection with the description of the flight control system, the Constitution hydraulic system is actually three separate systems. A 3000-psi pressure is used throughout, except for the brakes, which operate through a pressure reducer. While other manufacturers had already been using 3000 psi on their airplanes when the Con-

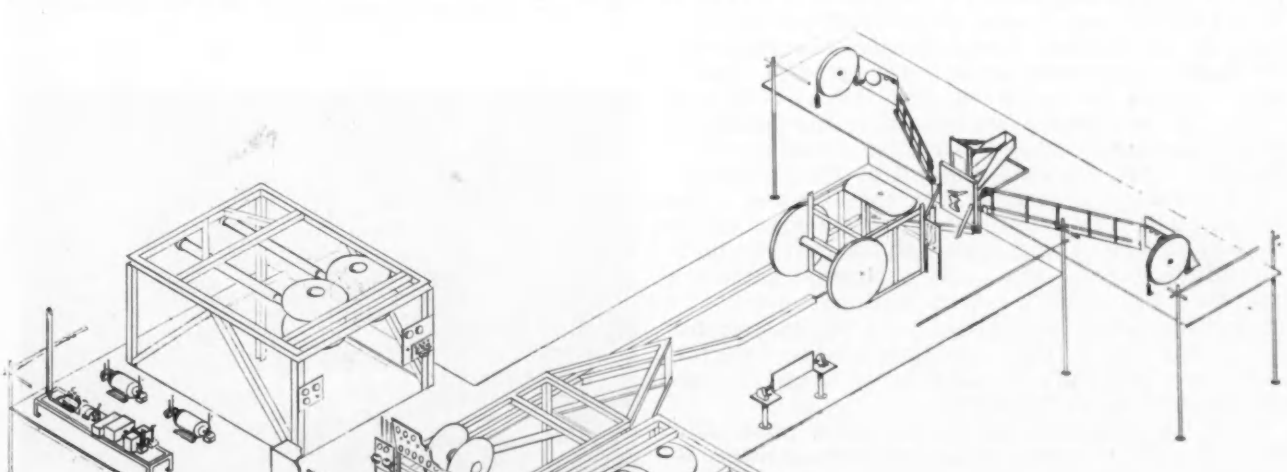

Fig. 1—Hydraulic system mockup

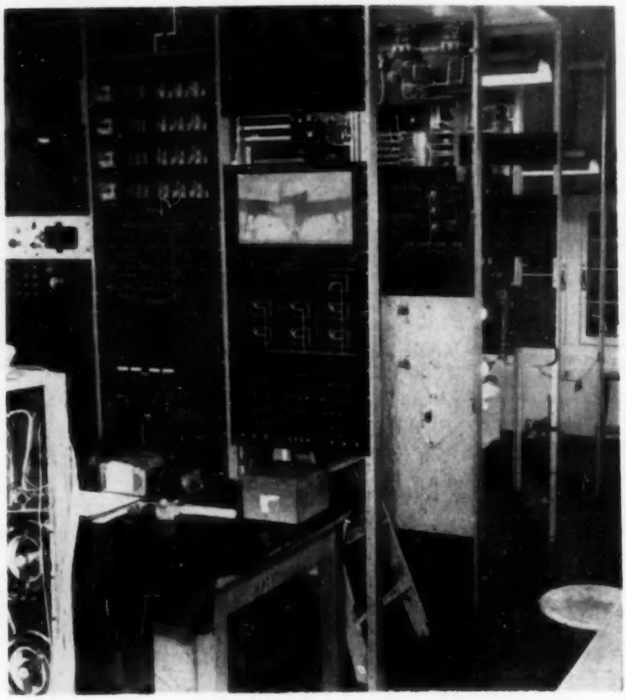

Fig. 2—Electrical system mockup

stitution design was begun, the power requirements needed on this airplane were far beyond any previously experienced. It was, furthermore, anticipated that the control booster system might develop some problems not inherent in the lower-pressure systems used on the Constellation and P-38. This, and numerous valuable lessons learned on the Constellation development, led to the decision to build a complete full-scale working mockup of the entire hydraulic system as designed for the airplane. The cost of such a program was obviously high but it unquestionably proved many times over to be a sound investment. The detail problems that arose and were successfully solved during the mockup testing, including life testing, were responsible for eliminating many time-consuming delays during flight tests, to say nothing of being the most reliable assurance of safety in flight.

Since the power requirements under peak load conditions for controls, flaps, landing gear actuation, and the like, were so high, it made the number of hydraulic pumps needed to do the job very large. No large pumps were developed and available to help alleviate this problem at the time, so it was necessary to install three pumps on each engine to do the job. Had pumps of larger capacity been available, they could have helped reduce the number to, perhaps, eight instead of twelve. However, there are certain indirect advantages to having the smaller pumps since, like multiple engines, they provide an added degree of safety should one fail.

A thirteenth pump is installed in the fuselage, powered by two electric motors geared together. This additional source of power has multiple uses. While the airplane is parked or is being towed, it provides hydraulic pressure using the ship's batteries or a ground cart for electrical energy to permit operation of the brakes and nose wheel steering. This electrically driven pump may also be used to check out the control system booster and flap system on the ground as part of an inspection or preflight check.

All of the valves used throughout the hydraulic system are electrically actuated and have a manual override lever to permit hand operation in the event of electrical power failure. Every valve is accessible in flight, since wing and nacelle access is provided by a tunnel leading out of the fuselage. In addition, the numerous valves in the tail cone are also accessible in flight through a man hole in the aft fuselage pressure bulkhead. Electrical operation of valves has a big advantage from many aspects. It is obviously simple to route wiring from switches to valve actuators when compared to cable actuation. On such systems as the main and nose landing gears, the problem of sequencing door operation is much easier when micro-switches can be used. The small electric motors used to operate the valves are 400-cycle a-c types and have no brushes, thus altitude problems usually associated with electric motors having brushes are nonexistent. A standard motor gearbox unit was developed and is used throughout on all types of valves, regardless of function, thus simplifying the spares problem.

Fuel System

The first problem to be faced in designing the fuel system in any airplane is the location of the fuel tanks. The quantity of fuel being known as a result of selecting an operating range was found to be such that the wing compartments could be arranged so

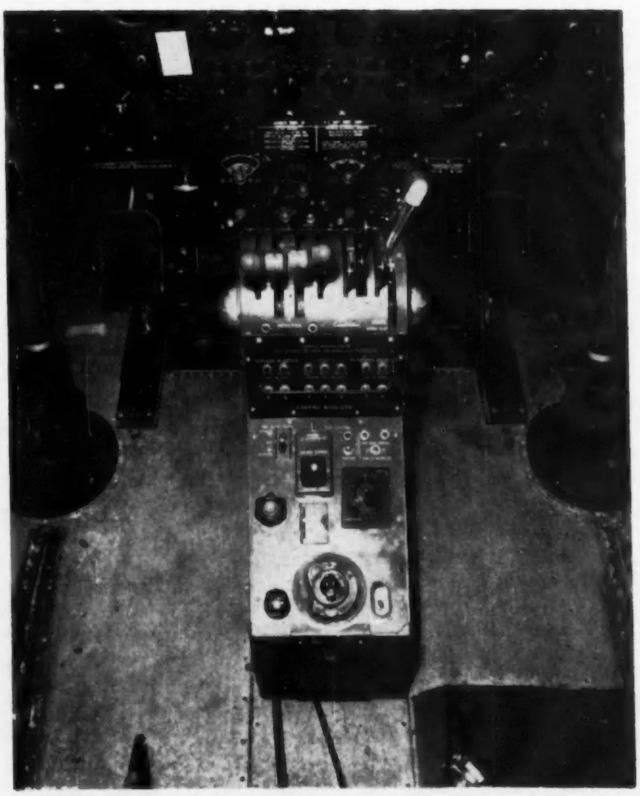

Fig. 3—Trim tab switch

that an extremely simple and basic system could be designed. Apart from a fuel tank arrangement consisting of one large tank with all engines feeding from it, the next simplest appeared to be one fuel tank for each engine. It is on this latter premise that the wing cells were arranged. Total capacity of the tanks was to be approximately 10,000 gal with approximately 8500 gal needed for long-range operation.

The next decision was probably the most difficult one—integral tanks versus bladder cells. At the time this decision had to be made, the experience with integral-type fuel tanks was far from satisfactory. Numerous airplanes were in service with integral tanks and fuel leaks were too serious to pass over lightly. The development of new and better sealing compounds and application techniques was showing real progress, but it could not be said that a fix was fully developed. Lockheed had accumulated perhaps more experience with this type of tank than any other airframe manufacturer and was fully aware of the seriousness of the situation. In spite of this, it was felt that a satisfactory integral tank could be developed in order to retain the weight advantage.

The approach to a successful tank would, however, have to be different from that used in the past. All of the attractive aspects of integral fuel tanks could be best summarized by saying "more fuel in less space." This had, unfortunately, led to the tank being just a section of standard wing structure sealed off by whatever means could be devised. This philosophy had been largely responsible for the poor reputation established for integral tanks. On the Constitution the problem was approached from a different angle. Instead of sealing off a normal section of wing, the tank area was established and the wing structure was designed to fit the tank, instead of vice versa. Without going too deeply into details, the basic policy followed through the Constitution tanks involved stopping all of the internal spanwise wing structure at each tank rib and picking it up within the tank without carrying elaborate structural shapes through the tank walls, which required complicated sealing devices. Feeling that this would practically eliminate the tank leakage, the project went forward and service experience later proved that the tanks were definitely a success.

Control Arrangement

As already explained, the tanks were arranged one to an engine. The control arrangement for the fuel system is, therefore, very simple. For all normal engine operation, the fuel control problem is nonexistent. In order to handle emergencies with the engine-out condition, a cross-feed system is provided, which makes it possible to feed any engine from any tank to provide the flight engineer with the means of balancing fuel load. Fig. 5 shows this clearly without requiring a detailed explanation.

The complete airplane fuel system was mocked-up in an operating manner so that altitude performance could be simulated and many refinements of such details as fuel plumbing routing were worked out so as to provide the airplane with the best fuel system installation under altitude and maneuvering conditions. Plastic transparent tubing was used throughout in the fuel system mockup in order to permit the detailed examination of the fuel flow and critical breakdown points when operating under altitude conditions.

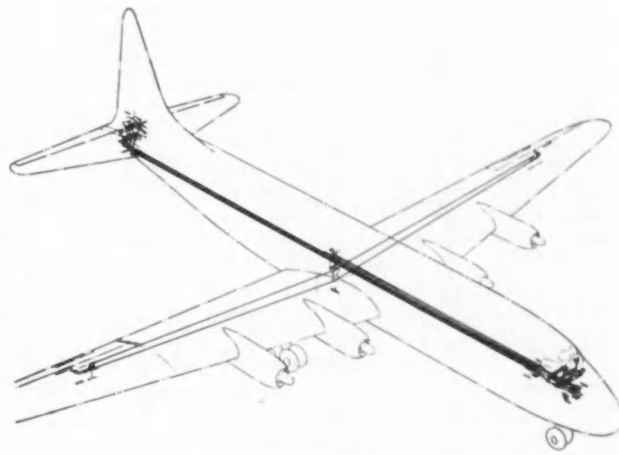

Fig. 4—Control system diagram

Air Systems

Cabin Pressure and Recirculating System—When considering the cabin air supply system, perhaps the first point of interest is the pressurization supply source and control mechanism. The pressure of 10,000 ft in the cabin at 25,000 ft amounts to an operating pressure of 4.67 psi. The source of air pressure is the engine exhaust-driven supercharger system. Since the airplane is designed to operate at a crusing altitude of 25,000 ft, each engine is equipped with a turbosupercharger. Thus, there exists a natural source of pressure air without mechanically driven supercharging. In order to provide adequate safety and to take care of inherent leakage of the fuselage when pressurized, a predetermined quantity of air is bled from each turbosupercharger for pressurizing the cabin. Based on previous experience obtained on the Constellation, an assumed rate of fuselage leakage, to be expected in service, was 30 lb of air per min. To assure sufficient safety margin, it was decided that each power source should contribute 30 lb of air per min or a total of 120. Not only would this give plenty of fresh air to the cabin, but it would assure adequate supply in the event of engine failure.

In order to control pressure, as well as rate of ascent and descent within the fuselage, a completely automatic outflow valve is installed immediately behind the flight engineer. This valve is a large bell-mouth plug type, which is motor actuated and was designed and built for the specific job by Minneapolis-Honeywell. The sensing mechanism is so arranged to to measure the differential pressure between cabin and outside air. In addition to being able to regulate the outflow valve to maintain a preselected pressure in flight, the mechanism also controls the rate of pressure change so that the effective climb or descent rate within the cabin is within acceptable limits regardless of the actual airplane

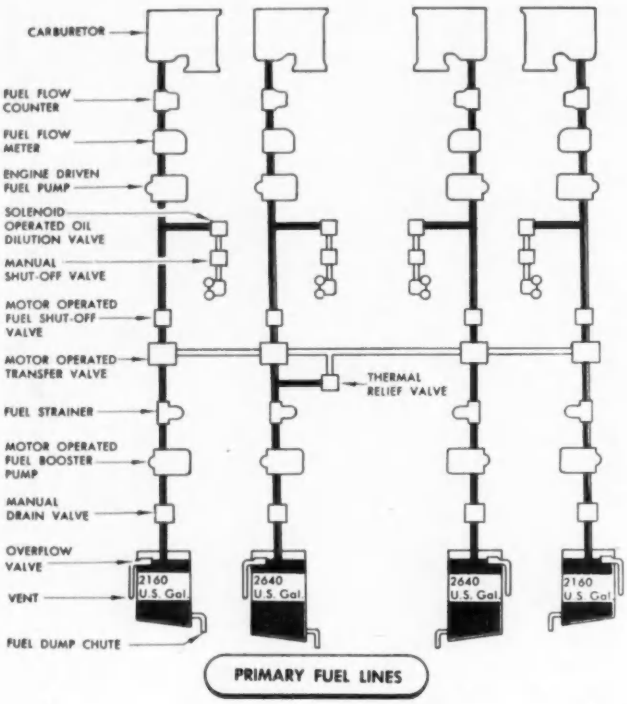

Fig. 5—Fuel system diagram

performance. As an emergency feature, the mechanism protects the cabin from excess pressure regardless of any errors that may be made in selection of pressure. To protect the airplane further there is a pair of large pressure relief valves installed at the tail cone, which are spring-loaded and operate at excessive pressure without any external power requirements.

To assure adequate distribution of the cabin air throughout the occupied zones, as well as to conserve the air supply, a recirculating system is used. Briefly, this amounts to forcing the air through a distributing duck-work by means of a 7½-hp axial-flow fan that handles approximately 440 cu ft of air per min. The recirculation of air is accomplished by forcing air into the cabin from ceiling ducts and drawing it into the plenum chamber between decks made up of lower deck ceiling and upper deck floor. The air is then drawn through activated charcoal filters for odor removal and thence back through the recirculation fan to be mixed with clean incoming air. Based on the design leakage rate and overboard dumping resulting from pressure control, the air within the cabin under stabilized altitude conditions is approximately half fresh and half recirculated air. Fig. 6 illustrates the extensive air ducting system necessary to accomplish the desired distribution and control.

It should be mentioned that the air that enters the odor-producing areas such as galley and lavatories is ducted immediately overboard through outflow valves rather than being drawn through the recirculating and filtering system.

Cabin Heating and External De-Icing System—The prime source for heating cabin, wing, and tail surfaces is the engine exhaust system. A large heat exchanger is installed in each of the engine exhaust tail pipes so that all of the exhaust, under all operating conditions except take-off, passes through the exchanger.

The cabin is divided into four basic zones, each isolated from the other. This, in terms of heating, means that the heat requirement in each zone can differ widely from any other, depending not only on volume but on the type of load carried in each. It is evident that when the passenger cabin is occupied by 92 persons releasing their normal body heat, the heat requirement at any given ambient outside temperature will be considerably less than would be the case of a half-filled cabin. Similarly, the lower deck sections may carry cargo or passengers and, under these extremes, the heat requirement would differ markedly. Because of this, the heating arrangement is divided to handle each zone independently. Heated air, which has been passed through the primary heat exchangers, is ducked into the cabin in stainless-steel tubes. It is acknowledged that this air may become contaminated by leaks in the heat exchangers, so, in order to prevent such air from entering directly into the cabin, a set of secondary heat exchangers is installed beneath the aft lower deck floor. The clean cabin air leaving the recirculating fan is ducted through this battery of heat exchangers before entering the zones for which it is intended. The amount of heat picked up is regulated by a thermostat located in each zone, which controls a dump valve, regulating the amount of hot air permitted to cross-flow through the secondary heat exchanger. The heated air coming from the primary exchangers is thus dumped overboard in amounts commensurate with the heating needs within the cabin. The capacities of the heating systems for the cabin are such that there is sufficient heat available to maintain the cabin at 70 F when the outside ambient air temperature is at −65 F.

The wing and tail de-icing systems derive their heat from the same source as the cabin. The normal arrangement, with all four engines operating, is set up such that the outboard engines supply heat for the wing leading edges outboard of the nacelles and between the nacelles. The inboard engines then de-ice the short section of leading edge between those nacelles and the fuselage, together with the fuselage and tail leading edges. The same stainless-steel duct used to get heat to the secondary fuselage heat exchangers is used to carry heat back through the fuselage to the tail. A transfer valving arrangement is provided to assure the wing and tail of enough heat under all conditions, even at the expense of the cabin.

The manner in which the heated air is distributed to wing and tail surfaces follows generally conventional practice. This consists of an inner skin with corrugations, which form a path for the heated air to follow chordwise after being permitted to enter at the extreme leading edge. To assure proper flow and uniform distribution in a spanwise direction, the apertures at the exit end of the corrugations must be accurately sized and a path for the air to follow through the wing to a low-pressure area must

provided. In the Constitution this path follows the wing leading edge access tunnel in the case of the wing, and aft through the wing flaps and aileron gaps. For the empennage, the air exists out through the elevator gap.

Systems Operation

Electrical System—The original concept of the electrical system had to be completely changed prior to the first flight of the prototype because the constant-speed drive and alternator had to be abandoned. A temporary electrical power system was installed in the prototype, consisting of two apu's driving a-c alternators. This was purely an expedient to allow flight tests of the airplane to start. While flight tests of the prototype continued, the electrical system was redesigned to make use of a 120-v d-c generator system. One of these generators was installed on the prototype to obtain service experience. When the second airplane was flown, it was equipped with the 120-v d-c system. One of the major electrical system problems that had to be worked out in flight was cooling the 120-v generator. A successful cooling configuration was finally arrived at, consisting of an inlet cooling duct and an exhaust duct from the generator dumping overboard. This exhaust duct served two purposes:

1. To increase the flow by exhausting into a low-pressure area.

2. To assist in fire control in the event of a generator fire.

Main Landing Gear Wheel Prerotation—Each wheel was provided with a flat pancake type of motor having a rotating field on the inside of the stationary armature. With the change in the electrical system from an a-c primary system to the high-voltage system (120-v), Lockheed developed with Dever the prerotation motor for the 120-v system. Each engine-driven 120-v generator drives the prerotation motors for a pair of wheels. Therefore, loss of any generator drops one pair of prerotation motors. The inrush current was found to be 75 amp per motor, which decayed to 20 amp after 2 min of operation. The motors turned the wheels to an equivalent speed of 80 mph ± 10%. The main service troubles that were uncovered during the flight test program were with the brushes and brush holders.

The standard operation was to turn on the prerotation upon turning into the base leg of the landing pattern. After 2 min of operation, the wheel speed was approximately 90% of maximum. At 4 min, the field winding was at maximum temperature. Upon contacting the ground, the prerotation motors are shut off by the main landing gear scissors switch.

As regards use of vanes on tires, it was found that if the vanes started the wheels turning, naturally the starting torque on the motor was greatly reduced. However, the running torque with vanes is increased. The vanes would always turn the front wheels but, on most occasions, the rear wheels would

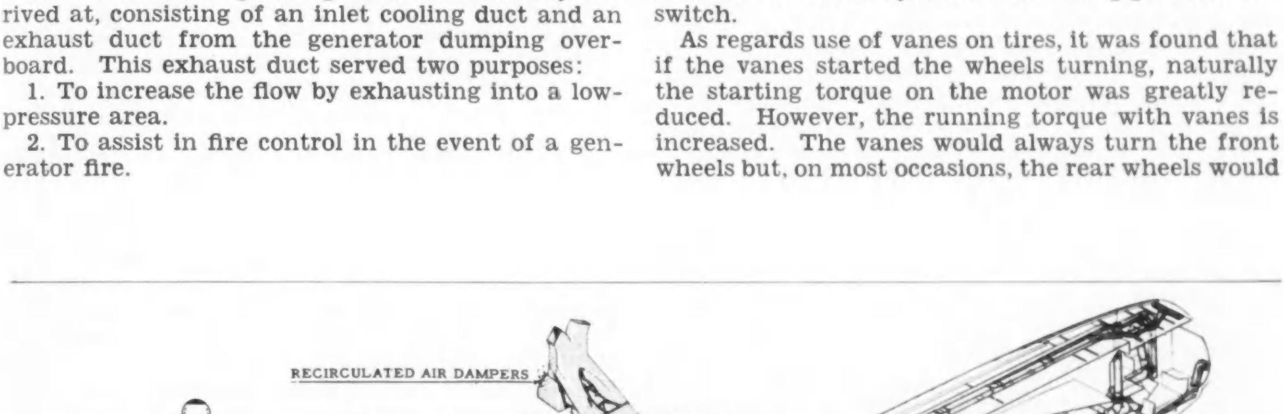

Fig. 6—Air conditioning duct system

not turn, being in the wake of the front wheel. Consequently, the breakaway torque required of the motor had to be based on starting from a completely stopped condition.

The success of the landing gear wheel prerotation was due in a large part to the Hayes type of brake installation, since it was demonstrated that the breakaway torque, immediately after brake application, was less than 3 ft-lb, whereas the breakaway torque, immediately after brake application, on another type of brake was greater than 20 ft-lb. This is important under conditions of wave-off where it must be assumed that some brake application was used heating up the brakes, and that the prerotation would be used shortly thereafter on the second approach.

Hydraulic System—The very extensive laboratory tests of the complete hydraulic system, including the surface control power boosters, landing gear, and the like, were demonstrated to be worth while by the absence of hydraulic system problems during the flight test program. One failure that showed up in the flight test program that was not uncovered by the laboratory tests was fatigue failure of 24S-T lines having small bend radii. This was undoubtedly due to the absence of vibration in the laboratory tests. It was definitely the opinion of the flight test crew that the laboratory tests paid for themselves because, except for relatively minor difficulties similar to the one just mentioned, the hydraulic system performed extremely well and required little or no redesign during the flight test phase. One item that disclosed a difference between laboratory and actual flight test was concerned with landing gear operation. The rigidity of the structure and the simulated air loads on the landing gear apparently were not the same as in flight because deformation of the structure resulted in binding of the downlocks. This was corrected by providing more clearance.

Fuel System—The hot fuel climb corroborated the laboratory tests of the fuel system remarkably well, the pump critical altitude with 110 fuel checking the laboratory results within 400 ft of altitude. One modification to the fuel system that had to be made as a result of flight test was to provide a surge box in the fuel tanks to keep the tank outlet from unporting during the very steep descent, which occurred in a power-off approach with flaps down and at flap placard speed. This angle was 14 deg. It was also necessary to modify the fuel dump system to keep fuel from touching the stabilizer tips during dumping. The flight test airplane was provided with fuel totalizers on each engine to facilitate fuel-flow measurements and satisfactory control. This proved to be so valuable that it was adopted as standard equipment on both airplanes.

Air Conditioning System—Flight tests indicated that the airflow and distribution in the cabin were satisfactory, but the cockpit needed considerably more air than was originally provided. Ducting was modified to correct this condition. One feature of the presurization system that proved of great value was the manually controlled outflow valve in the flight engineer's station. In the event of difficulty in the electrical part of the pressurization system, the flight engineer could conveniently control cabin pressure. One change that was made in the air conditioning system in the galley was in anticipation of a possible fire hazard. The air was exhausted from the galley over the stove through ducts that connected with other ducting leading to the outflow valve. It was thought that a flash fire in the galley could possibly cause a conflagration if it entered the exhaust ducting. Consequently, this ducting was removed and the galley air was exhausted directly overboard through a sonic venturi.

Thermal De-Icing—Initial tests of the thermal de-icing under dry-air conditions indicated that the anti-icing air temperature exceeded the limit of 300 F and locally heated some wing leading edge structure above the Navy specification of 250 F. There was a further limitation imposed to limit the temperature in areas that contained unaged 24S-T to 200 to prevent corrosion and reduction of strength. All areas in vertical and horizontal stabilizers were affected by this limitation. Temperatures in all areas were reduced to an acceptable value by increasing the airflow through the primary heat exchanger by providing a cold-air passage through the center of this heat exchanger. Upon completion of development work required to provide suitable dry-air performance, actual experience was obtained during icing conditions and indicated satisfactory de-icing.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

SAE Summer Meeting Report

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ARE YOU AN EXECUTIVE?

Here an executive of duPont answers this question via common denominators of executives he has known

BASED ON PAPER BY

Chaplin Tyler, Development Department, E. I. duPont de Nemours & Co., Inc.

• Paper "Are You of Executive Caliber?" was presented at SAE Philadelphia Section, Jan. 10, 1951.

WHAT are the broad characteristics common to the most capable executives?

They are energy or drive, effective intelligence, and effective relationships with people.

This selection is based upon personal observation of those executives with whom I have worked closely at various times over a period of 30 years. Among these men were educators and editors, line and staff executives, young men and "old timers."

Energy or drive is manifest by a great capacity for work, coupled with constructive direction of personal effort. It is channeled to achieve results for the organization rather than for the self and it is infective for it impels or motivates effort in others.

The capable executive is a determined person. He has a sense of direction, a plan, and a timetable. He finishes with the same drive that he starts with. The 10 best men known to me seem to be motivated by something other than hope of monetary reward or broadened power. They give the job all they have and let material reward and better position come as they will.

Effective intelligence involves more than possession of intellect. An executive must be able to think a problem through which means to define it, resolve it, then decide on a practical course of action. He is intellectually honest and he thinks straight.

The best executive is a thinker. This role is often overlooked because the executive spends so much time working with people. But he must be a thinker, because, in the last analysis, he must make decisions, and sound decisions base on sound reasoning.

Effective relationships with people is developed to a high degree by my best executives. All are approachable, all are good listeners. They are unconscious of rank. With respect to superiors they take orders and accept constructive criticism without rancor. They collaborate unstintingly with associates and strive to evoke cooperative effort among subordinates.

Some people call the quality that evokes cooperation "leadership ability;" I call it effective relationships. The good executive sets the standard of behavior. By showing sincerity, honesty, and cooperation in dealing with others, he evokes a similar behavior.

It seems pointless to weigh these broad characteristics of energy, effective intelligence, and effective relationships. The man of high caliber, like a well-balanced team, operates as a total organism. The three attributes are essential and none can say that one component is more important than another.

Have You "Top Brass" Metal?

Do people look to you to get things done?

Are you in demand to head committees?

Are you asked to analyze tough problems or merely asked to contribute data?

Have you contributed substantially to the advancement of your business?

Do you enjoy working with people?

Do you jump at the chance to boost an associate?

Jet Fuel Control Systems

EXCERPTS FROM PAPER BY

F. C. Mock, Bendix Products Division, Bendix Aviation Corp.

• Paper, "Turbojet and Turboprop Engine Controls," was presented at SAE Annual Meeting, Jan. 10, 1951.

DEVELOPMENT of fuel control systems for jet engines presents a number of engineering and administrative problems. These points require serious thought and consideration:

What are some of the special difficulties of the jet control engineer in meeting military demands?

Who should supervise selection and adaptation of a fuel control for a given jet engine and airplane?

Procurement procedure for complex military airplanes is a most difficult problem for jet control engineers. The specification method, as now applied to both experimental and new model production equipment, has this drawback: specifications must be drawn broadly if they are to act as an incentive to better standards of performance or construction. But broad specifications are not conducive to a favorable system of parts standardization, so important in modern war. The basic problem is how to combine a steady rise of development with required production standardization at suitable intervals.

Specifications therefore should develop as a practical compromise. Such an approach, to be effective, requires consultation with all parties concerned—the control engineer, the engine engineer, and the airplane engineer.

A few years ago, development of controls for production airplane engines was definitely assigned to the engine manufacturer. While this procedure does not tend towards standardization, it probably will be retained because of procurement and administration advantages. But it is highly important that more emphasis be placed on the necessity of coordination of all the divisions of engineering involved in control application.

A more complete system of comparative flight test evaluation of controls would be an important step in the direction of reasonable standardization—if fairly and adequately conducted. Certainly no standardization should be attempted without such an evaluation.

The decision as to who should supervise the selection and adaptation of a fuel control for a given jet engine or airplane is a difficult one. It requires balancing these four engineering requirements.

a. Fuel metering method, control design, and manufacturing procedure. Requirements of reliability, space, and weight justify special construction for aircraft. Efforts to adopt practice from other fields (steam turbine controls) have not been especially encouraging.

b. There must be complete up-to-the-minute knowledge of engine characteristics and requirements. This might indicate that controls should be designed by the engine builder. But the past record of the internal-combustion engine shows that a major percentage of the advances in fuel metering were made by fuel metering specialists. However, there have been instances where engine men made outstanding contributions.

c. Any control dvelopment must be tied in closely with flight conditions and phenomena, and performance in the air. No one has gotten around this requirement.

d. Familiarity with the routine method of handling and various operational demands made upon the control in the particular service for which it is intended. . . . military training, military combat, or commercial use.

These requirements involve the control designer and manufacturer, the engine builder, the airplane builder, and the eventual user of the airplane. Which should be set up as the project engineer to properly harmonize the requirements of all?

Present Unusual Problems

Expediency dictates imposing this responsibility upon the engine builder. These additional requirements should be taken into consideration.

a. The man acting as the Project Engineer should not regard himself only as an employee of the engine company. His job is to coordinate efforts of the control builder, airplane builder, and engine builder in meeting requirements of the final user of the control. Some may reject this as impractical, but in the long run it is probably to the best interest of the engine company. If such a policy is not followed, eventually the final user will insist on dictating the selection of controls.

b. It must be continuously kept in mind that the objective is improved flight performance under service conditions, using only the usual service personnel.

c. The man in charge should be of mature experience, the administrative rather than the inventive type, and free from prejudice and pressure from any source. He should be connected with no competing development projects of his own company.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

The Situation on Gas Turbine Fuel Control . . . .

THE gas turbine fuel control situation appears to be in a state of confusion. The following is believed to be a fair summary of the present status.

1. Engine builders build almost two separate control types for each engine, all differing widely in operational characteristics, functional requirements, and requirements for repair and calibration service. (A serious burden in case of widespread war)

2. Military specifications call for generally uniform flying characteristics.

3. A reasonable degree of automatic starting and restarting is achieved with certain controls. With others, the inexperienced pilot—by using hot starts—runs a considerable risk of damaging his engine.

4. Some controls are relatively dependable mechanically. Others of different construction do not have such good records.

5. Controls in use in the Korean war (all of one type) appear to be quite satisfactory in service. But this point seems to receive little consideration in the intensive procurement of new engine types.

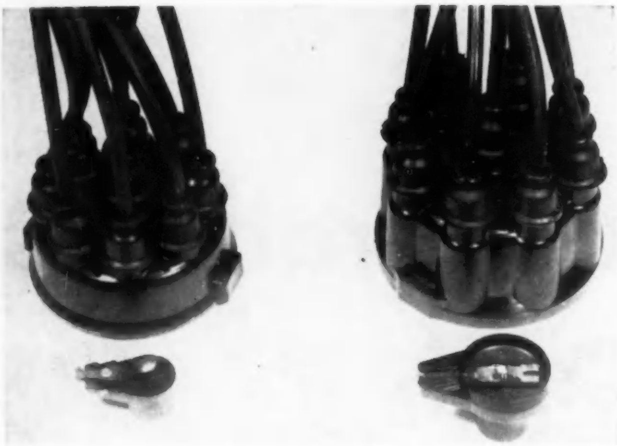

Fig. 1—Standard distributor cap and rotor (left) and all-weather distributor cap and rotor (right)

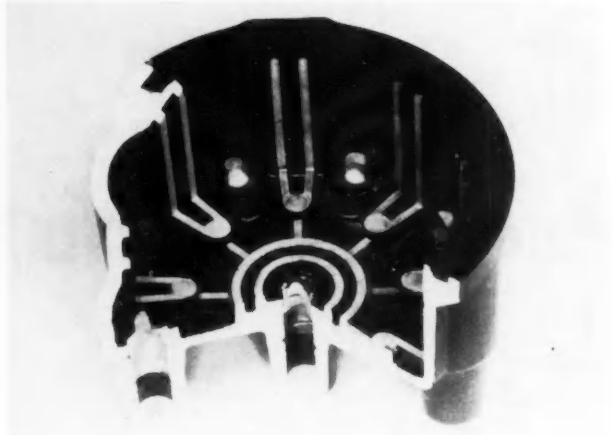

Fig. 2—Cutaway view of all-weather cap showing square-cornered ribs—to improve arcover characteristics when wet

How to Keep Your

BASED ON PAPER BY

H. L. Hartzell and **B. H. Short**

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• Paper, "Ignition Problems in Damp Weather," was presented at SAE Annual Meeting, Detroit, Jan. 10, 1951. This paper was published in full in the April issue of SAE Quarterly Transactions.

MANY measures can be taken to minimize the effects of moisture on ignition systems that are not required to operate submerged or under heavy splash conditions. Listed in the degree of their effectiveness, these are:

1. Replace braid-lacquer-covered cables with neoprene-covered cables.
2. Install tightly fitting, durable nipples on all towers of the distributor cap and on the coil output terminal.
3. Install tightly fitting, durable nipples on all spark plugs.
4. Provide adequate distributor ventilation.
5. Replace distributor cap and rotor with units having their contouring designed to minimize the effects of moisture.

For submersion or heavy splash conditions, special designs have been developed that give effective protection.

Protection from Moisture

Even ignition systems that don't operate submerged or under heavy splash conditions must be protected from the film of moisture that may be deposited over the coil high-tension surfaces, the secondary cables, the distributor high-voltage surfaces, and external portions of the spark plugs.

Condensation of moisture from crankcase vapors inside the distributor cap can also become a serious problem when distributor ventilation is not adequate. This menace to satisfactory ignition can be minimized by distributor cap design or eliminated completely by supplying positive ventilation.

It has frequently been demonstrated that in actual operations the braid-and-lacquer-covered cables soon become sources of ignition loss when wet. When the lacquer coating becomes cracked, the braid acts as a wick to carry moisture a considerable distance along the cable. The wet braid then becomes an effective conductor and leaks ignition energy to the high-tension cable supports. For this reason neoprene-covered secondary cables have already been widely accepted by the industry. The merit of using tightly fitting nipples on the towers of the distributor cap and the coil high-tension outlet has also been accepted as effective insurance against the loss of ignition energy under moisture conditions.

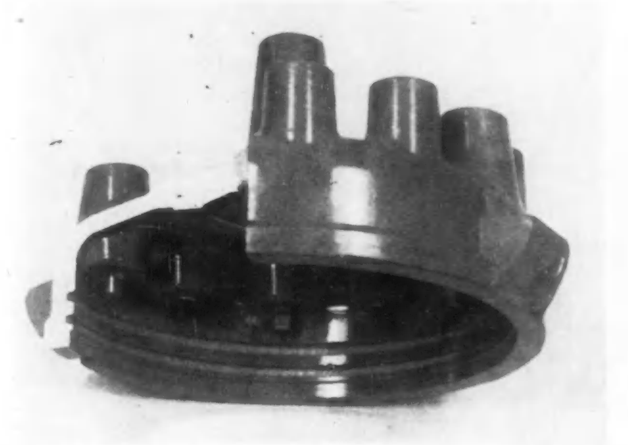

Fig. 3—Cutaway cap showing contouring of internal surfaces, which is effective in breaking moisture film

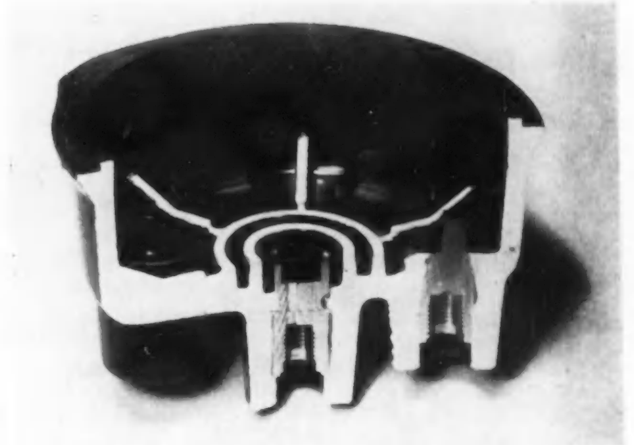

Fig. 4—View showing ribs, which are very effective in preventing tracking between inserts

Ignition System Dry

1. When system won't be submerged
2. When system might be submerged

To obtain quantitative data on the effect of moisture, various components were tested under synthetic conditions considered similar to those in actual service. The units to be tested were first cooled to 0 F, then they were placed in a test room with a relative humidity of 55% and a temperature of 72 F.

A coating of frost first appeared, from the condensation and freezing. When the frost melted, a uniform deposit of moisture was formed over all the surfaces. Voltage measurements were made while this moisture film was present.

The spark plugs were screwed into a bomb through which air was allowed to flow under pressure. The pressure was increased to prevent sparking at the plug electrodes. The flow of air was sufficient in volume to prevent the accumulation of moisture on the internal surfaces of the plugs.

To simulate the coating of dust and oil that usually accumulates on the components of a vehicle, the parts were painted with a solution of motor oil dissolved in carbon tetrachloride. When the solvent had evaporated, there was a thin coating of oil over the surfaces to be studied. The units were then placed in a box containing agitated AC spark-plug cleaner test dust prepared according to Army specification. The resultant coating closely approximated the appearance of that found on components in actual service.

Two types of tests were made. In each test the total capacity of each secondary circuit was held constant at 50 micromicrofarads (when dry). In one group of tests the energy input to the ignition system necessary to give 15-kv output from a clean dry system was determined. This value of input was then used while the output voltage available under the various conditions of moisture and dirt was determined. In this way the decrease in secondary voltage from the condition under study could be evaluated.

These tests showed that, when the plug was clean, moisture condensation reduced the available voltage by only 7%. A dry coating of oil-dust had even less effect, for it reduced the voltage by only 3%. When the oil-dust-coated plug was given the moisture treatment, however, it dropped the available voltage by 52%. Since in service most plugs will accumulate a dirt coating, unless kept finically clean, this condition often prevails. When this is true, the

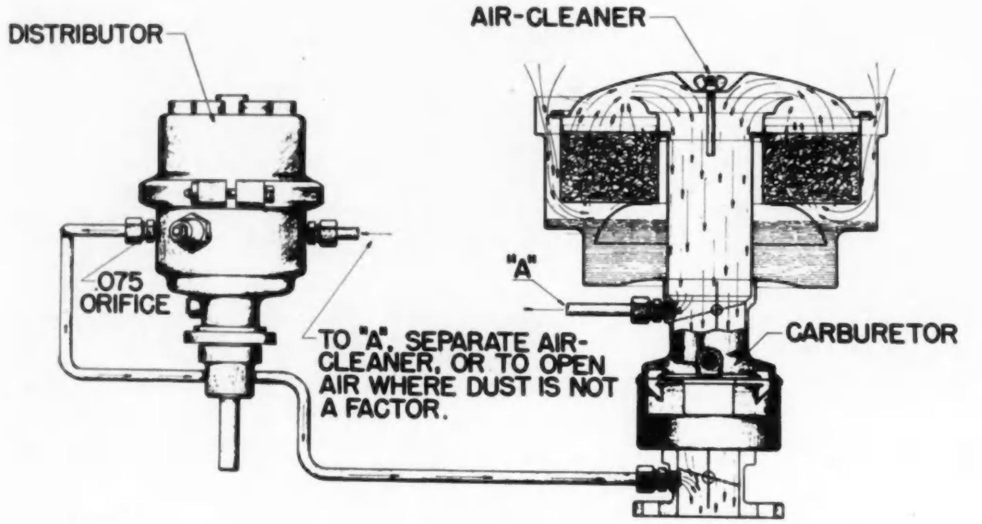

Fig. 5—Recommended ventilation system for sealed distributors

engine will not start or operate satisfactorily, for the ignition reserve is not sufficient to permit a loss of anything like 52% of the available voltage.

(That the synthetic conditions of this test were equivalent to those found in actual service was verified because the oscillogram that was taken during this test checked closely with observations made from plug-lead assemblies that has been operated in a vehicle for 20,000 miles.)

Further tests showed that the loss in voltage can be minimized by using a tightly fitting nipple, even though it is dirty and wet. In this case the voltage decrease was only 5% of the voltage that was available with a new, clean, and dry plug.

Study of a number of spark-plug nipples disclosed, however, that because of the high temperature at this point and because of the ozone that is formed in this region, some currently available nipples soon lose their effectiveness. There may be a variety of materials and many variations in shape that will do a good, durable, waterproofing job, but plenty of performance and durability testing should be required before any of them are approved.

Tests of the standard distributor cap and rotor indicate further that a dirt coating does not decrease the available peak voltage as long as the parts are dry. Moisture on the clean cap decreases the voltage by 20%, and moisture on the dust-coated cap drops the voltage by 33%. This decrease was also closely approximated by a test on a distributor cap and rotor that had accumulated their own oil-dust coating during 30,000 miles of regular operating service. Obviously, such decreases are of intolerable magnitude, and indicate that some correction should be made.

One of the better commercially available nonwettable coatings was also studied. The tests showed that its use greatly improves the situation while the cap is clean and wet, having reduced the loss from 20% to 2% in the tests. When the cap had accumulated an oil-dust coating, however, this treatment decreased the loss in voltage from 33% to 28%. Thus, the lacquer coating does not appear to be an effective treatment, for in actual operation the caps do become dust-covered.

A study of contours for insulating surfaces indicated that a given number of ribs is less affected by moisture when the ribs have sharp corners than when they are rounded. It was also found that more ribs used in a given length of path result in a greater flashover voltage.

As far as possible, the technique gained from the tests was incorporated in a new distributor cap and rotor—called the all-weather cap. It is compared with a standard cap and rotor in Fig. 1. The interior contours are shown in Fig. 2. Note the generous use of a number of sharp-cornered ribs in each of the possible leakage paths. This cap, because of its larger size and greater separation betwe(n in-

Table 1—Flashover Potential and Reduction Caused by Moisture

	Flashover Potential, kv		% Reduction Due to Moisture
	Dry	Wet	
New Spark Plug	23.0	20.0	13
Dirty Spark Plug	22.5	17.5	22
Dirty Spark Plug and Nipple	32[a]	32[a]	0
Clean Standard Distributor Cap and Rotor	33.0	23.5	29
Dirty Standard Distributor Cap and Rotor	31.0	21.0	32
Lacquer-Coated, Clean Standard Distributor Cap and Rotor	35.5	31.0	13
Lacquer-Coated, Dirty Standard Distributor Cap and Rotor	31.0	23.0	24
Clean All-Weather Cap and Rotor	36.0	35.0	3
Dirty All-Weather Cap and Rotor	35.0	33.0	6

[a] This was the maximum voltage available from the ignition system in use. The spark plug did not flashover either wet or dry.

erts, is capable of handling higher voltages than the standard type.

When encrusted with dirt and wet this new cap dropped the available voltage by only 10%.

The system with the standard cap and rotor and with no spark-plug nipples drops the available voltage by 53% when oil-dust coated and wet, while the combination of the all-weather cap and rotor and the nipple-covered plugs reduces the voltage by only 12%.

Another series of tests showed that dirt on the spark plug causes some decrease in the flashover voltage, but that dirt and moisture further lower it to the range of normal ignition voltages for some engines. Installation of nipples raises the flashover voltage far beyond any ignition requirement encountered, even in the latest high-compression engines.

The standard cap and rotor have a flashover potential when dirty and wet that is very close to the ignition requirements of those high-compression engines. Coating with moisture film repellent lacquers does not materially improve this condition.

The new all-weather cap has flashover ratings, on the other hand, when both dirty and wet, that are well above any known ignition requirements. It is a happy coincidence that the same measures that minimize the losses in voltage when the components are wet are also most effective in increasing the arcover rating under the same conditions of wetness. A summary of flashover voltage data is given in Table 1.

There are installations where the distributor cap is sufficiently cooled by the engine fan so that crankcase vapors coming into the distributor lose their water by condensation onto the inner surfaces of the distributor cap. This moisture promotes arcover on the inside surfaces of the cap. After a comparatively short time these arcs are apt to establish burned tracks over the surfaces, resulting in cap failure. Contouring of the internal surfaces, as shown in Fig. 3, is very effective in preventing the formation of conducting paths to the distributor base casting. Ribs as shown in Fig. 4 have been very effective in preventing tracking between inserts.

The introduction of hot air into the distributor and the forced air ventilation system shown in Fig. 5 are positive cures for this trouble.

Protection from Complete Submersion

Complete submersion of the ignition system can be expected in military vehicles. Fig. 6 shows a system designed for this type of service. It has the

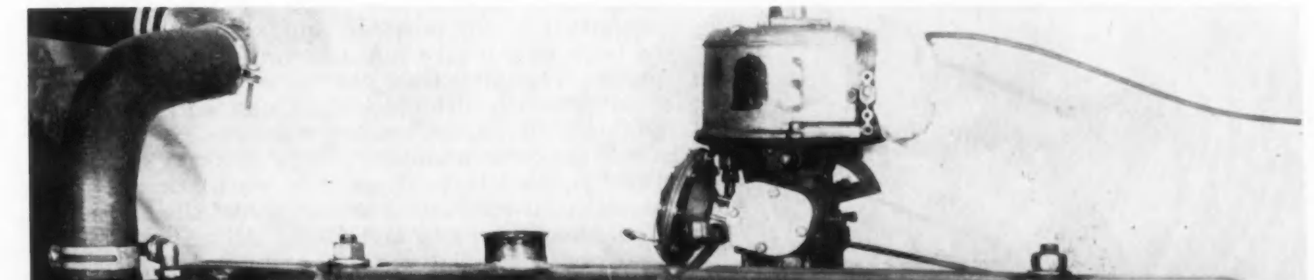

Fig. 6—Waterproof ignition system that meets military specifications for submersion. It is also suppressed for radio noise

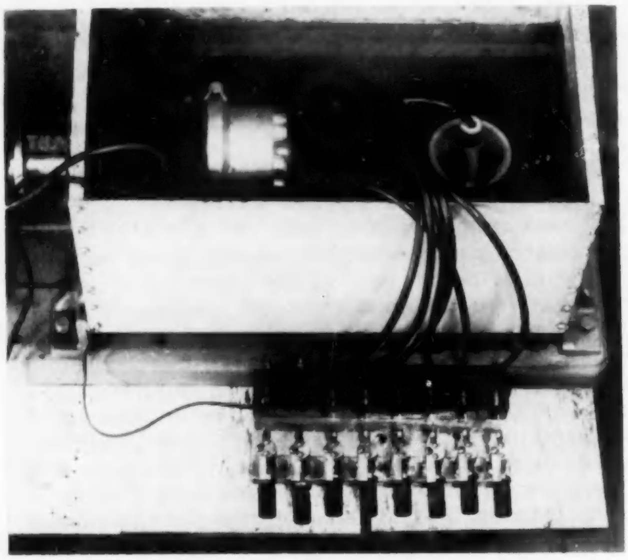

Fig. 7—Submerged ignition system

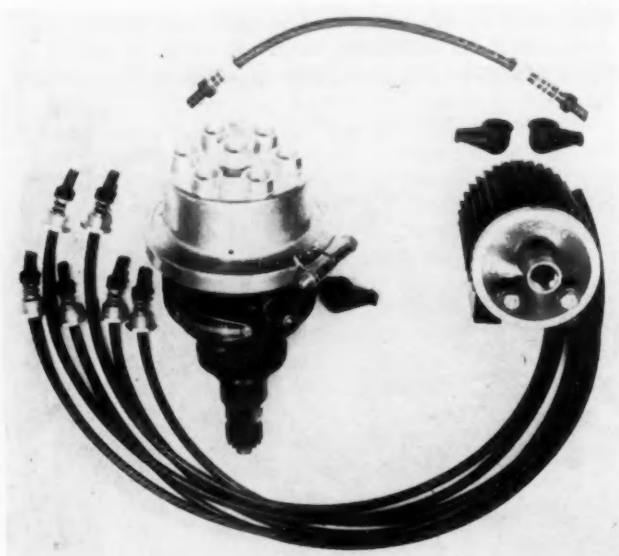

Fig. 8—Components for system shown in Fig. 7

ignition coil built into the distributor housing. The entire distributor is sealed to prevent the entrance of moisture, and ventilation is secured by drawing air from the air cleaner through the distributor to the intake manifold. The high-tension leads are enclosed in waterproof conduits, which are sealed by means of spring-loaded gaskets at both the distributor and the spark-plug ends. This system has proved adequate, even when submerged in salt water. The conduit is not necessary for waterproofing, as the seals can be applied directly to the leads. The covering is used here for radio noise suppression.

A second system in which the secondary leads are not shrouded is shown in Figs. 7–9. This arrangement, when used with shielded and sealed spark plugs, is satisfactory for fresh-water submersion. It is also recommended for use when the engine of a coach is mounted below the floor, so that it is subjected to continual splash in wet weather.

This system requires a high grade of elastomer-covered high-tension cable. These cables are sealed into the distributor and coil high-voltage outlets by spring-loaded gaskets, as shown in Fig. 9. With this system the distributor must be force ventilated by methods similar to those already described, and as shown in Fig. 5.

Some undercoach engine installations have been used with rubber or leather boots enclosing the distributor and the adjacent leads. This method has rarely been satisfactory, partly because adequate ventilation is not provided and, secondly, because the boots do not give sufficient protection from the splash. The inadequate ventilation permits the accumulation of nitrous acid, which corrodes and roughens the circuit breaker cams, which, in turn, causes excessive breaker rubbing block wear. Another trouble arising from poor ventilation is the formation of conducting tracks across the surfaces of the distributor cap and rotor. All of the effects of poor or no ventilation may be eliminated by using the system shown in Fig. 5.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

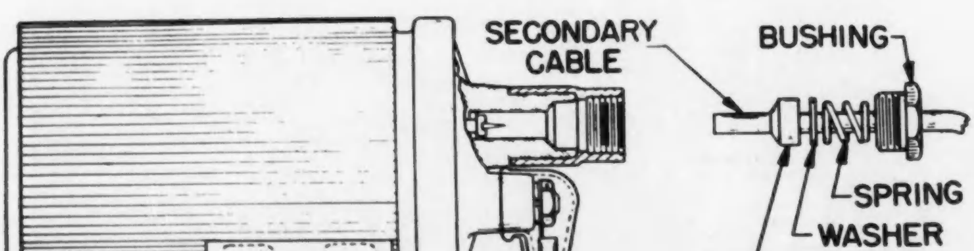

Fig. 9—Sealing details as used in system shown in Fig. 7

DIESEL ENGINES are being developed to give increased power output while burning fuels of no higher grade than formerly—in fact, in some cases, while using fuels of lower grade. Such improvements are providing the incentive to develop oils—now known as Series 2 oils—with additional additives, to counteract the effect of the resulting higher concentrations of incompletely oxidized products and acids formed in the combustion process. The greater additive concentration of these lubricants increases their unit cost and hence they must be used as efficiently as possible. The authors have endeavored to analyze the situation, and to suggest how their efficient use could be achieved.

The complete paper consists of two parts. The first outlines a laboratory method used to determine economic oil drain intervals for a stationary 4-cyl diesel engine. Upon consideration of the experimental data, the authors make some generalizations concerning changes in lubricating oil properties and engine wear. On the basis of these observations and calculations pertaining to basicity and engine wear, certain specific recommendations are proposed affecting oil drain practices.

The second part of the paper presents field test data for several diesel engines of the same makes but of various sizes, which operated more than 15,000 hr on work schedules using extended oil drain intervals with a commercial Series 2 crankcase oil. The effects of operating conditions and operating time between crankcase oil drains on both engine wear and cleanliness are examined in these extensive tests.

The last section of the paper—in which the authors give an economic comparison between operation with 2-104B and Series 2 lubricants—is presented here.

Series 2 Oils Pay Their Way

BASED ON PAPER BY

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F. E. Kronenberg, Caterpillar Tractor Co.

and

J. M. Plantfeber, Shell Oil Co.

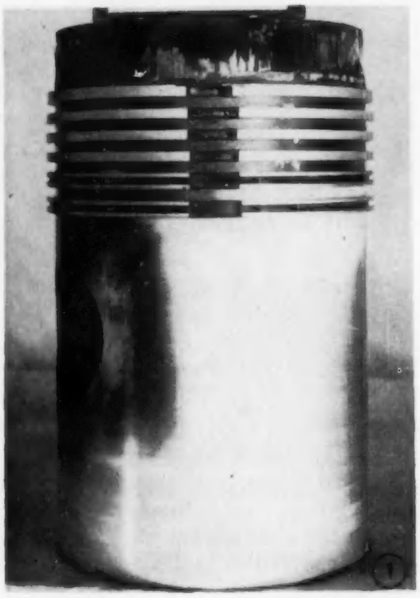
• Paper, "Series 2 Oils Pay Their Way," was presented at the SAE Annual Meeting, Detroit, Jan. 9, 1951.

EFFORTS to reduce operating expenses caused by undesirable deposits and wear in diesel engines have frequently included the use of premium-grade fuels and much-shortened drain periods. Often, however, the lubricating oil, fuel, or engine repair costs have actually turned out to be higher than before these techniques were used.

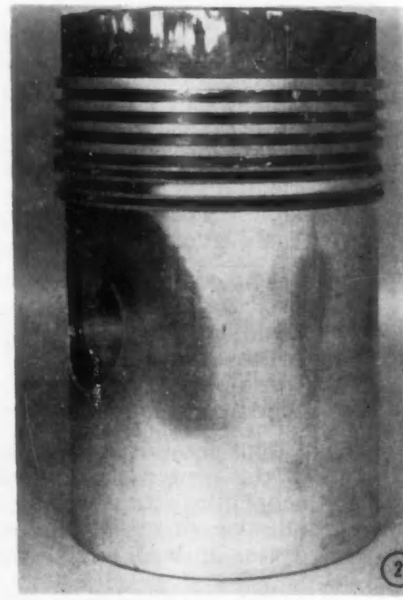
The use of Series 2 oils, on the other hand, may accomplish the desired result, as indicated by the examples shown in Fig. 1. In this figure operation and costs for several engines of one make are compared when these different approaches to the problem were tried.

In all cases costs are calculated on a crankcase capacity of 10 gal and a conservative oil consumption of 30 hr per gal.

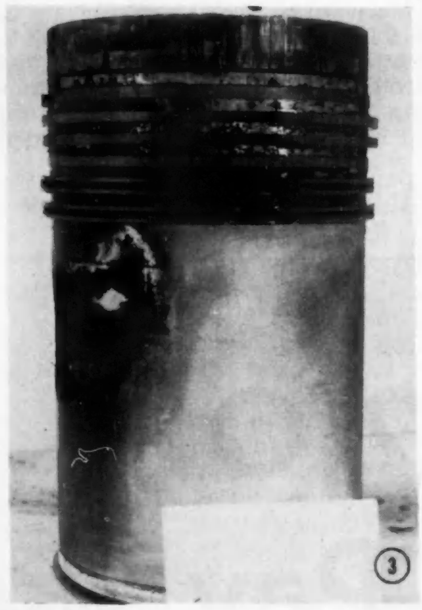
Pistons 1, 2, and 3 of Fig. 1 are from engines in which 2-104B oils were used. Piston 3 was removed from an engine engaged in marine-propulsion service, and represents 1032 hr of operation using a conventional 2-104B oil with 240-hr drain periods and a regular grade of fuel having a 0.34% sulfur content. The oil costs were $45 in this case, but obviously the operator was faced with a premature repair bill. Piston 1 was removed from an engine used as a pumping unit for a deep well in Arizona. Premium-grade fuel was used for 3744 hr, together with 2-104B lubricating oil. The results were better than in the previous case, although the premium



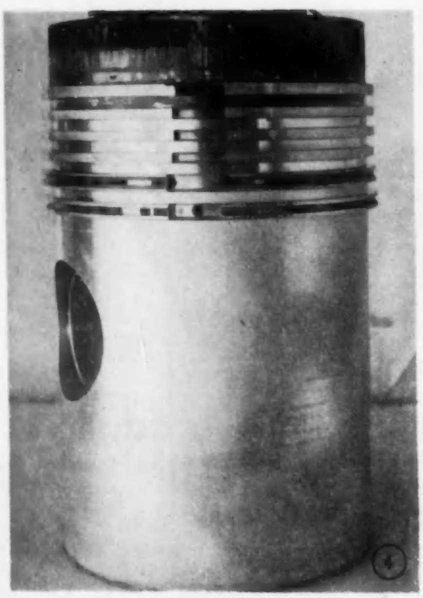
240-hr drains
$165 per 1000 hr (oil and increased fuel cost)
75 gal 2-104B oil at 60¢ per gal
Premium fuel (0.15% sulfur) 6000 gal
Cost at 2¢ per gal $120
95% carbon No. 1 groove
0.0015 in. per 1000 hr liner wear
0.015 in. per 1000 hr top ring gap increase (nonchrome)
3744 hr



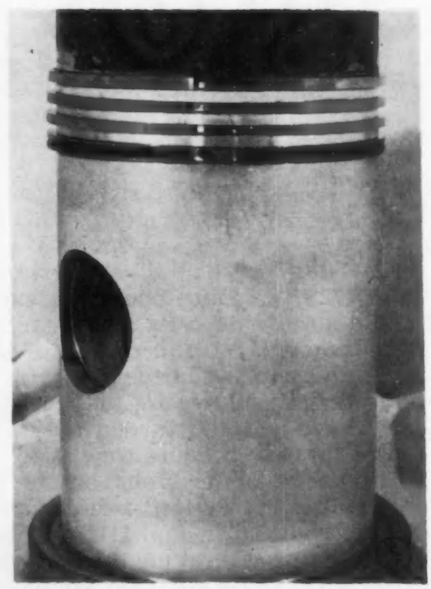
60-hr drains
$120 per 1000 hr (oil cost)
200 gal 2-104B oil at 60¢ per gal
Regular fuel (0.5% sulfur)
70% carbon No. 1 groove
0.0025 in. per 1000 hr liner wear
0.015 in. per 1000 hr top ring gap increase (nonchrome)
4682 hr



240-hr drains
$45 per 1000 hr (oil cost)
75 gal 2-104B oil at 60¢ per gal
Regular fuel (0.34% sulfur)
100% carbon No. 1 groove
0.007 in. per 1000 hr liner wear
Stuck top rings
1032 hr



260-hr drains (1-500 hr)
$65 per 1000 hr (oil cost)
72 gal Series 2 oil at 90¢ per gal
Regular fuel (0.75% sulfur)
60% carbon No. 1 groove
0.0013 in. per 1000 hr liner wear
0.020 in. per 1000 hr top ring gap increase (nonchrome)
1838 hr



500-hr drains
$48 per 1000 hr (oil cost)
53 gal Series 2 oil at 90¢ per gal
Regular fuel (1% sulfur)
1% carbon No. 1 groove
0.0006 in. per 1000 hr liner wear
0.008 in. per 1000 hr top ring gap increase (chrome)
2901 hr

Fig. 1—Piston conditions and operating costs with 2-104B and Series 2 oils

harged for the fuel plus the cost of the lubricating oil resulted in a cost of $120 plus $45, or $165 per 1000 hr of operation. Piston 2 comes from an engine run for 4682 hr to power a drill rig mud pump, again using a 2-104B oil, but draining every 60 hr. In this case the fuel had a sulfur content of 0.5%. The results were passable, but, in spite of the short drain intervals with a medium sulfur fuel, the deposit level was higher than desired. This, combined with the cost of $120 per 1000 hr for lubricating oil, hardly permits a reasonable level of economy.

Operation with Series 2 Oils

Piston 3—from the marine-propulsion unit that failed at 1032 hr when 2-104B oil was used—should also be studied in relation to pistons 4 and 5 from engines operated with Series 2 oils. Piston 4 is from a pumping unit using regular fuel with a sulfur content of 0.75% and drain intervals between 260 and 500 hr in length. The cost of the Series 2 lubricating oil was $65 per 1000 hr in this case. Piston 5 was removed from a tractor engine operated with 1% sulfur fuel and a Series 2 lubricant for 2901 hr and using a drain period of 500 hr. Here, the lubricant cost came to $48 per 1000 hr of operation.

The data of Fig. 1 are presented as representative of field conditions and the selection of subjects was made to indicate the fallacy of dependence on fuel of premium quality or short drains as a substitute for quality of lubricating oil in the search for desired engine results and operating economy.

Fig. 2 shows pistons removed from the engines represented in Fig. 1 (pistons 1-3), following the field tests of Series 2 oils operated for the customary maximum drain period of 240 hr for 2-104B oils.

Benefits to Owner

Each owner benefited beyond the improvements provided by the oil, as:

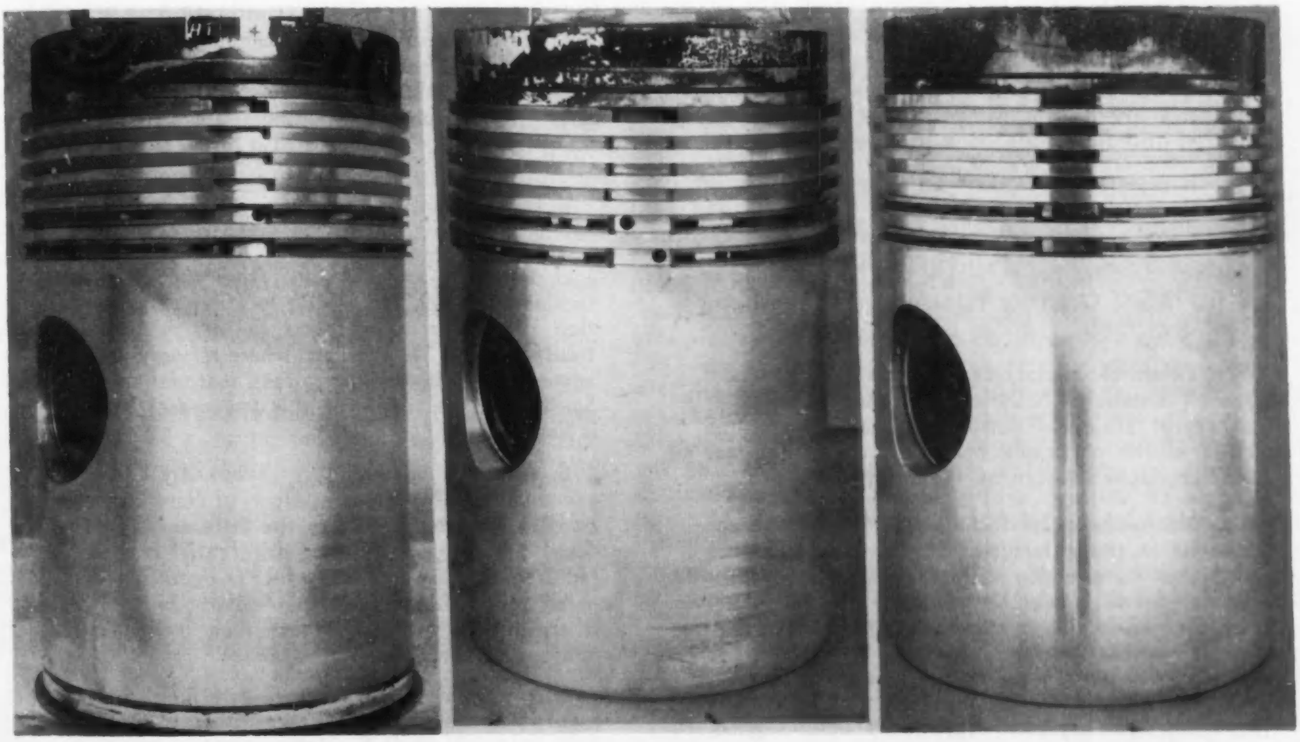
1. He was able to avoid costly repair bills at premature hours.

2. He was able to operate satisfactorily with regular diesel fuel having 0.6% sulfur.

3. The one who had moved to an area of high sulfur fuel (1%) was able to obtain satisfactory results with 240-hr drain periods.

Each engine presented conditions that indicated the possibilty of extended drain periods and influenced the initiation of the present project.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



Marine-propulsion unit
Regular fuel (0.34% sulfur)
1400 hr

Deep well pump engine
Regular fuel (0.60% sulfur)
1373 hr

Powering drill rig mud pump
Regular fuel (1% sulfur)
1947 hr

Fig. 2—Pistons removed from engines following field tests on Series 2 oils operated for customary maximum drain period of 240 hr for 2-104B oils (engines used in these tests are same as those represented by pistons 1-3 in Fig. 1)

Liquefied Petroleum Gas as

BASED ON PAPER BY

Leonard Raymond, Socony-Vacuum Laboratories

• Paper, "Liquefied Petroleum Gas as a Fuel for Automotive Vehicles," was presented at SAE National Fuel and Lubricants Meeting, Nov. 9, 1950.

THE liquefied petroleum gases referred to as LPG include propane, propylene, normal and isobutane, and butylenes.

The principal sources of LPG are crude oil wells, natural gas wells, gas distillate wells, and refinery operations.

Some of the principal properties of pure propane and butane are listed in Table 1 together with data on average commercial products. These materials are known as liquefied petroleum gases because while gaseous at normal temperatures and pressures, they liquefy rather easily under pressure. Thus, while propane will boil or vaporize at -44 F at atmospheric pressure, at 100 psig it is a liquid at +60 F.

Both propane and butane are essentially odorless. Since they are flammable products, a large number of states and municipalities have specified that an odorant be added in accordance with the standards of the National Fire Protection Association to permit the vapor, which is heavier than air, to be readily detected in case of a leak. Common odorants used in LPG in the past several years are sulfur compounds of the mercaptan type such as ethyl or isopropyl mercaptan.

The composition and properties of commercial LPG will depend upon the source. The products from gasoline and recycling plants contain only the saturated normal and isoparaffins. Refinery production will contain appreciable quantities of unsaturated or olefinic hydrocarbons such as propylene or butylene. In addition, the particular blend used for LPG will depend on the supplier, the locality, and climatic conditions.

LPG may be essentially 100% propane or butane or mixtures of the two. Butane has a higher boiling

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IN his complete paper, which will be published in full in SAE Quarterly Transactions, Mr. Raymond concludes that:

1. Potential availability of liquefied petroleum gas on a national basis will continue to be far in excess of projected demand for some years, the chief source of supply being the crude and gas well production region of the Southwest.

2. No fundamental technical difficulties appear to exist in the automotive use of LPG. Engines of higher compression ratio, now available, compensate for the lower heat content of LPG. Fuel consumption in miles per gallon equivalent to gasoline is possible.

3. The growth of automotive use of LPG nationwide has been erratic. Volume declined slightly during the last two years.

4. LPG installations—including engine, storage, dispensing, and ventilating equipment—cost considerably more than gasoline facilities.

5. Delivered price of LPG from the Southwest production fields varies with locality. Transportation is a major item of cost to the highly industrialized areas. In the East, where refinery propane appears to be lower in cost than material from the Southwest, the supply of this lower cost material is limited.

6. Although maintenance needs are reduced, economics of LPG versus gasoline- or diesel-powered coaches is keyed chiefly to the differential in fuel cost. Stability of the price differential is a major factor in projecting costs of LPG operation compared to the other fuels, particularly in the East where the differential is less than in the other sections of the country.

7. Any system under pressure with highly volatile fuel is basically less safe than gasoline. Some local authorities have prohibited the storage, transportation, and use of LPG. With approved equipment and extra installation features and with additional care in use and servicing, the safety record probably could be as good as gasoline.

Vehicle Fuel

First of a Series

The accompanying abridgment of Mr. Raymond's paper is the first in a series of five digests, which SAE Journal will carry in consecutive issues, on the subject of liquefied petroleum gas as a motor fuel.

As one of the papers to be digested points out, LPG as a direct motor fuel could go a long way in cushioning the essential civilian economy against the impact of military requirements for aviation and other gasolines in wartime. Besides, finding uses for LPG is important to the conservation of our natural resources—the petroleum industry is likely soon to find itself with a gallon of LPG for every gallon of gasoline in its petroleum reserves.

Authors of papers which will be digested in this series are, besides Mr. Raymond, R. C. Alden, F. E. Selim, M. J. Samuelson, and A. J. St. George.

point (31 F) and a lower vapor pressure than propane. This difference is not of great importance in the case of automotive equipment, in which sufficient heat is available to vaporize the LPG before its passage to the carburetor. But in household heating and other installations, such external heat may not be available, and the LPG must vaporize readily and completely in the fuel tank under the conditions of external storage.

Therefore, the milder climates—as in California—will permit greater percentages of butane in LPG blends than the colder sections of the country. In California it is possible that relatively more butane may be available for LPG use because of the lower Reid vapor pressure of gasoline permissible for freedom from vapor lock. Thus, LPG blends in California may consist of as much as 70% butane and 30% propane. On the other hand, in the northeastern section of the country with its colder temperatures and with other means of disposing of the butanes, LPG in most cases is commercial propane.

Where refinery processing is the source of commercial propane, as in the Northeast, the product generally contains appreciable quantities of propylene, one analysis showing approximately equal percentages of almost 50% each of propylene and propane with small amounts of ethane, ethylene, butane, and butylene. The vapor pressure of the commercial propane shown in Table 1 is somewhat higher than the pure propane due to the presence of small amounts of the more volatile ethane and ethylene.

The potential availability of LPG is much greater than present sales. A potential of 250 to 350 million barrels per year or 10–15 billion gallons per year from natural gas and cycling plant production is estimated. In comparison, approximate sales of 3 billion gallons are forecast for 1950. An additional large volume of LPG is potentially available from refineries, which are estimated to have supplied 1 billion of the 3 billion gallons sold in 1949. A very large proportion of the refinery production is now applied to other uses, including motor fuel production as a major item.

Other factors besides abundance affect the market position and acceptance of a raw material. Cost of transportation is a key item, as has been the case in a number of large-volume industries. Thus, the Baltimore-Philadelphia-New York harbor area handles an estimated 400,000,000 gal (10,000,000 bbl approximately) of LPG per year, although the automotive demand for this product on the East Coast is virtually non-existent, price undoubtedly being a deterrent. Of the 400,000,000 gal, about one half is supplied by refineries, the remainder coming in by tank car and one pressure tanker.

The largest use of LPG in internal-combustion engines is in the state of California where, it has been estimated, 2,000 trucks and 20,000 units of farm and highway construction equipment use one third of the total LPG consumed in the United States by internal-combustion engines. A number of petroleum companies on the West Coast, including General Petroleum, have tried to promote the use of LPG in automotive equipment for the past 15 years with indifferent success. Erratic changes in supply and demand and price undoubtedly have affected LPG acceptance, the change in price from 4¢ to 8¢ per gal about two years ago apparently causing a serious set-back. In addition, the entry of higher powered diesel engines has also had its effect on interest in LPG as a motor fuel.

One supplier estimates that the consumer will have to be able to buy propane for three quarters the price of gasoline to break even with gasoline. Since price is the major factor affecting the attractiveness of LPG in any area, the decision of any operator considering change to LPG-powered equipment undoubtedly would be influenced to a considerable extent by the stability of the price differential between gasoline and propane.

The stability of the price structure will vary with different sections of the country, those areas within easy reach of the producing fields undoubtedly being assured of a low and more stable price than the

Table 1—Principal Properties of Propane and Butane

	Propane	n-Butane	Commercial Propane	Commercial Butane
Boiling Point, F at 760 mm Hg	-44	+31	-51[a]	+15[a]
Freezing Point, F at 760 mm Hg	-306	-217		
Specific Gravity, liquid 60/60	0.5077	0.5844	0.509	0.582
Specific Gravity of Gas, 60 F at 760 mm Hg	1.5222	2.0065	1.52	2.01
Weight, lb per gal	4.223	4.863	4.24	4.84
Btu per lb, gross	21,490	21,134	21,560[b]	21,180[b]
Btu per gal, gross	90,752	102,774	91,500[b]	102,600[b]
Air required for combustion, lb air per lb fuel	15.65	15.43	15.58	15.3
cu ft air per cu ft fuel	23.82	30.97	23.4	30.0
Flammability limits, vol. % in air mixture	2.37–9.50	1.86–8.41	2.4–9.6	1.9–8.6
Vapor Pressure, psig, @ 60 F	92	12		
@ 100 F	174	37	192	59
@ 130 F			286	97
Octane Number, Motor	100	92		
Octane Number, Research	100+	95		

[a] Initial boiling point
[b] After vaporization

more remote industrial areas. As an example, in the Southwest and Middle West states surrounding the producing areas, LPG is expected to make considerable inroads in the farm tractor field. A number of LPG suppliers are promoting LPG application in this field, including some of the companies which are in undersupply on the East Coast. It has been estimated by one company that 30,000 tractors will be converted to LPG this year. Since this is a summertime demand, it will be valuable in helping level off the LPG industry's sales curve, hence its importance. Many of the farms in question use bottled gas for heating and other purposes, so the change to LPG may be somewhat easier than in other conversions.

Within the past 20 years, high-pressure tank cars and tank trucks have been developed to replace the 20–300 lb "bottled gas" cylinders for transportation of LPG. Bulk shipments now are made in 8000–12,000 gal tank cars and 3000–8000 gal tank trucks from the producing area or refinery to the bulk plants, at which points storage tanks with maximum capacity of 30,000 gal are used. While a greater part of the transportation is by tank car and tank truck, one company is using a 35,000 bbl (1,470,000 gal) capacity tanker which is a converted Type CIA dry cargo ship containing 80 high-pressure cylindrical tanks designed specifically to transport LPG. This tanker is said to be making two trips per month from the Gulf Coast to the New York area.

The same company has a bulk terminal of 2,500,000 gal capacity in the New York harbor area. Although there has been some talk of moving LPG by pipe-line, particularly in the Mid-West where large amounts of butanes are transported in this manner for motor fuel blending, little propane is being so moved due to lack of propane storage facilities and to the overloaded condition of the pipelines.

(Chief source of safety regulations for handling LPG is Pamphlet 58 of the National Board of Fire Underwriters.)

Transfer of LPG from a tank car or tank truck to a storage tank is made by one of several methods, all involving a closed system of pressure: (1) liquid pump, (2) vapor compressor, (3) air or gas pressure, (4) gravity. (See Figs. 1 and 2.)

Operators' storage facilities can be either above or below ground. Above-ground storage is preferred to underground because of lessened external corrosion, reduced cost, and ease of inspection. Vapor lock can also be a big problem in underground storage unless there is a gravity feed to the liquid pump.

The dispensing equipment to fuel the tank on the vehicle consists in substance of a liquid pump, a meter, a special dispensing nozzle, and a vapor line connection. Pumps of up to 20 gal per min capacity are available, the pump building up a differential pressure according to the setting of the differential valve, which may be as high as 30 lb.

The LPG vehicle tank, where it is used in a motor fuel application, is specified in NBFU Pamphlet 58 as having a minimum design working pressure of 250 psi for gases with vapor pressure between 175 and 200 psig at 100 F. The tanks or containers must be located in such a manner as to minimize the possibility of mechanical injury. The clearance must never be less than the minimum road clearance under maximum load, and fastenings must be designed with a factor of safety of four. The tank must be equipped with proper valves and connections, having a rated working pressure of 250 psig minimum and the piping from the tank to the first stage regulator must be nonferrous. The maximum size of a single vehicle tank is 300 gal water capacity. The fuel tank has to be cylindrical and will be at least 20% larger than the gasoline tank to achieve the same cruising range, due to the outage, or vapor space, volume. It may be a little difficult to accommodate a tank of the required dimensions in some conversions.

One tank which has been very strongly recommended for automotive use is shown in Fig. 3. It allows 23% for outage, the governing code in California specifying a minimum of 16.6% and Pamphlet 58, 20.2%. This type of tank is actually two

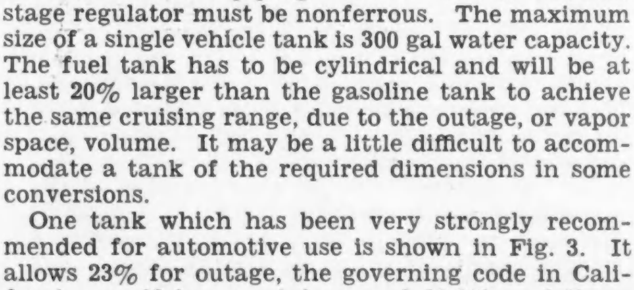


Fig. 1—Liquid pump transfer system

tanks in one, consisting of an inner vapor tank and a surrounding liquid tank. It is considered by some as a "must" for automotive applications since it virtually eliminates all possibility of the dangers of a liquid-full tank. The manufacturer has developed a very ingenious safety hose nozzle and tank filler valve which, acting together, shut off the outage or vapor tank during filling. The filling operation is said to be rapid and simple, the hose nozzle being slipped over the tank valve spud and turned 90 deg to engage the lugs. Pulling the handle down then actuates all valves, and the liquid tank is filled while the vapor compartment is shut off. When the hose nozzle and filler connection are disengaged, the outage tank is opened to the main tank.

The heart of the propane or LPG fuel system is the converter and carburetor. The converter is a combination pressure regulator and vaporizer, two-stage pressure reduction being used in many cases, with a jacket water-heated exchanger as a fuel vaporizer between the two stages. No fuel pump is required because of the positive tank pressure. The gas carburetor differs from the gasoline unit in that the propane is supplied as a gas or vapor, mixing with the air taking place in the gas phase.

A cold manifold is recommended to improve volumetric efficiency and because no need exists for vaporization of liquid fuel in the manifold. A higher compression ratio engine is permissible because of the high octane number (above 100) of propane and is also desirable as a means of compensating for the lower heat content or energy per gallon of propane compared to gasoline. It has been said that the use of propane in automotive applications would not be practical without the high octane number and the engine equipped to utilize the high antiknock quality. Cold spark plugs are desirable for longer plug life and better overall performance and are feasible because of the nature of the fuel compared to gasoline.

Theoretically, the heat values of chemically correct air-fuel mixtures of propane, butane, and gasoline respectively in a gaseous state at atmospheric pressure and temperature are essentially the same. Therefore, at a given compression ratio, disregarding all other factors, the same output from the three fuels would be expected.

However, since gasoline enters the engine induction system as a liquid, its vaporization after mixing with the air results in a drop in the temperature of the air-fuel mixture of approximately 50 F. Since propane is vaporized before admixture with air, this drop in temperature does not occur. In addition, the propane gas tends to displace some of the air in the manifold. The overall effect is a loss in volumetric efficiency and power output which may amount to 5%.

The replacement of the standard gasoline manifold and its hot spot with a cold manifold, protected from heat transmission from the exhaust manifold, will recover a considerable part of the loss in volumetric efficiency. In some engines, such as the Fageol and Hall-Scott in which the intake and exhaust manifolds are on opposite sides of the block, volumetric efficiency has been said to be slightly greater with propane. It is probable also that the better distribution of propane compared to gasoline and the more uniform air-fuel mixtures reaching each cylinder would tend to improve the power output.

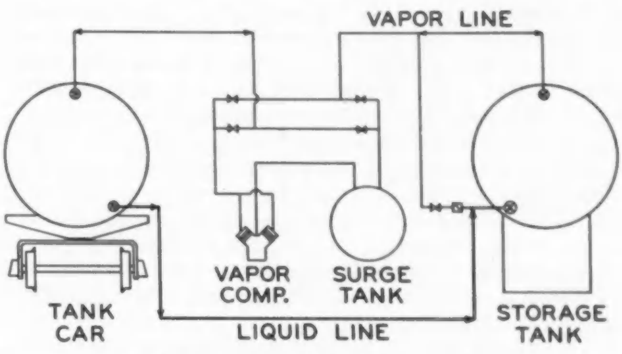


Fig. 2—Vapor compressor transfer system

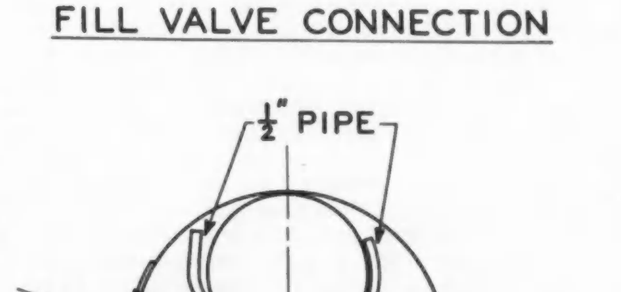


Fig. 3—Parkhill-Wade safety fuel tank in cross-section

Propane and butane, with their higher octane numbers than current regular grade gasoline, make knock-free operation at higher compression ratios possible, with resultant increase in power output.

Change in compression ratio can be accomplished by either change in cylinder head or pistons. In some cases, the increased power output and torque is greater than the capacity of the transmission system to the rear wheels. One manufacturer intends to retain the economy advantages of the higher compression ratio but to reduce the displacement in order to stay within the torque limits of the warranties on the drive line units.

Of course, not all engines are inherently capable of being changed to higher compression ratios.

In cases where compression ratio is raised, an extra load is placed on the ignition system due to the higher compression pressures and other factors. Based on our own experience with engines of up to 12 : 1 compression ratio, 12-volt systems generally

used in bus equipment are considered necessary to avoid misfiring at the higher loads. In addition, preignition due to hot electrodes becomes more of a problem at the higher compression pressures and temperatures, and the coldest possible plug is desirable. This is practicable with propane since spark plug fouling is reduced due to a minimum of fuel deposits. In one application of a modified engine in commercial service, special heavy-duty plugs including the use of platinum electrodes were found helpful at the higher ratio. A number of spark plug manufacturers have been cooperating in solution of the ignition problems associated with the higher compression ratios.

With regard to spark timing, although the basic flame velocity under laminar flow conditions for propane should not differ greatly from that of gasoline, it has been stated that velocity of burning in the engine is somewhat slower and the engine manufacturers have found that a somewhat greater spark advance of as much as 5-10 deg. is preferred. This apparently is at variance with some foreign experience in which the difference in maximum power timing was relatively slight and in the reverse direction.

The basic factor involved in comparisons of specific fuel economy of propane and other fuels is the heat or energy content. Propane has a slightly higher Btu content per pound than gasoline and diesel fuel. However, propane weighs only 4.24 lb per gal compared to 6.15 lb per gal for 60 deg API gasoline and 7.0 pounds per gallon for 37 deg API diesel fuel. In terms of gross Btu per gallon, the values are: propane, 91,500; gasoline, 125,000; diesel fuel, 137,000.

Higher compression, with its better thermal efficiency, is a necessary means of recovering some of the difference of 27% in energy between a gallon of propane and a gallon of gasoline. The theoretical gain, based on air standard efficiencies, in going from 7 : 1 to 10 : 1 compression ratio with gasoline is approximately 10%. However, additional gains in everyday operation can result from the more uniform distribution of the propane-air mixture, from the absence of an accelerating pump in the fuel system, and from the more complete combustion of propane, particularly during cold operation and warm-up, so that the mileage per gallon with propane has been estimated to be within 10% of that of gasoline.

Actual mileage experience in the field varies greatly from operation to operation, and direct comparisons of propane and gasoline mileage are practically nonexistent. One local company operating a number of LPG truck conversions has shown consumption figures based on reasonably long mileages of 4.4 mpg for gasoline at 5.0-5.75 compression ratio compared to 3.5 mpg for propane at 7.0-7.5 compression ratio. Another operator, who has recently converted a commercial gasoline engine to 9 : 1 compression ratio for propane reports 4.9 mpg on propane and 4.6 mpg on gasoline at the lower ratio.

In one California bus operation, a consumption of 2.66 mpg on propane and 4.07 mpg on gasoline is reported. In another California operation involving truck equipment, the consumption of propane and gasoline is reported to be the same at 3½ mpg. No details of the engine characteristics in these latter operations are available to us. A bus operator in South Dakota, who is also an LPG distributor, reported at the American Transit Association Omaha Conference in April, 1950 that, using substantially higher compression ratios on equipment converted to LPG use in 1947, the mileage was approximately the same as with gasoline. Another company which had operated over 100 buses on LPG in Spokane, Washington also reported approximately the same mileage for LPG as for gasoline. Twin Coach has reported slightly better mileage on its nominal 10 : 1 compression ratio LPG demonstration coach than on lower compression ratio gasoline coaches in relatively short tests in Chicago and Omaha.

These data are scanty and inconclusive and undoubtedly reflect differences in particular engines and operations, in the efficiency of the carburetion systems used, in the quality of the maintenance, and in the availability of proper test instruments for making correct adjustments. Opinions on LPG consumption compared to gasoline vary greatly, but if one wished to hazard an overall guess of fuel economy, a mileage for LPG ranging from 15% less than to approximately the same as gasoline might be estimated, with perhaps a somewhat greater burden on the new user to maintain the unfamiliar LPG equipment in good order. It should be borne in mind in such comparisons of economy that as gasoline antiknock quality improves and the compression ratio of gasoline engines increases, the proportionate gain in thermal efficiency with higher compression ratio will be less.

The maintenance comparison, like the fuel economy story, is also uncertain, being rendered more confusing by the greater complexity involved in maintenance operations and analysis, and the lesser accuracy of maintenance costs. The more volatile LPG is inherently a cleaner burning fuel than gasoline, leaving little in the way of residue in the engine and contributing practically nothing to engine deposits. Therefore, engine difficulties associated with fuel deposits would be expected to be very much reduced and longer time between overhauls should be anticipated. In addition to freedom from fuel-formed deposits, dilution of the crankcase oil will be eliminated, and reduced wear due to absence of the washing action of gasoline during starting has been claimed. The overall result is said to be an increase in overall time of 50-200%. The elimination of dilution has been reported to allow substantially increased oil drain periods. In addition, the volatile LPG should largely eliminate smoke and odor under conditions of proper engine operation. However, exhaust gas carbon monoxide contents similar to gasoline engines have been reported.

While conversion equipment for LPG operation varies considerably in price depending on the manufacturer and the completeness of the conversion, the current approximate cost of converting Fageol and ACF-Brill engines has been given as $350-$500. In the case of Fageol, this applies specifically to post-war units and includes higher-compression-ratio engine parts, high-pressure tank, converter, carburetor, and fittings. In the case of a new engine, the difference in cost between gasoline and LPG equipment is approximately $350.

Another cost item is the storage, dispensing, and ventilating equipment required with LPG. Depending on the size of the tankage and the dispensing and ventilating equipment, the cost of the facilities required has been estimated at from $0.60 to $1.00 per gal installed, in tank capacities varying from 6,000 to 30,000 gal. This assumes outdoor fuel storage and fueling facilities and exhaust fans and accessory equipment, including automatic alarms, for ventilating the garage in which the vehicles are stored. Since approximately 20% must be allowed for tank outage or vapor space, if 5000 gal liquid storage capacity is desired, a tank of 6000 gal volume will be required. Such a 5000 gal LPG capacity tank with the associated facilities will cost from $3600 to $6000.

One East Coast refiner, who currently has no LPG available for automotive use, has indicated that delivery, if LPG were available, could be made on the same frequency schedules as gasoline. However, the LPG suppliers in general, including those companies which are promoting the automotive use of LPG in the East and Midwest recommend a minimum of 10 days' storage capacity and up to 25 days if possible, particularly where refinery supply of LPG is relied upon, since refiners generally do not have over two days' storage capacity of LPG and a shutdown of a major cracking unit would reduce or cut off the supply. Thus, an operator with a fleet of 50 buses who uses 2000 gal per day of gasoline and now has 5000 gal gasoline storage capacity would require a minimum of 20,000 gal liquid LPG capacity plus 20% for outage, or 24,000 gal tank capacity. The cost of such facilities would be $15,000 to $24,000. If the fuel economy with LPG does not equal that of the gasoline-powered equipment, the capacity should be correspondingly higher. One LPG supplier is prepared to furnish this equipment under liberal lease terms and has estimated that for an operator using a minimum of 15,000 gal per month per installation, the delivery and storage charge exclusive of the ventilation facilities will be 1¢ per gal. The same supplier points out that due to the more expensive storage and handling equipment, the use of LPG is not economical unless rather large quantities can be handled in each installation.

The factor of greatest concern in the cost analysis is the fuel cost. There has been some misunderstanding of relative gasoline and LPG prices which requires clarification. In almost all cases, the pricing system for LPG differs from that of gasoline. The price of gasoline is generally quoted as a tank wagon price on the fuel delivered to the operator, whereas the price of LPG generally is based on tank car F.O.B. the refinery gate. Since the delivery costs for LPG are higher than those for gasoline, the differential in quoted prices for gasoline and LPG must be corrected for the difference in delivery and service cost, which will range roughly from 1 to 2¢ per gal.

The delivered price of LPG varies greatly over the country, being a minimum in the Southwest in the area of the producing fields and major sources of supply, and a maximum in the highly industrialized Northeast section of the United States due to the cost of transportation.

In the Southwest section of the country, LPG is available at 1½ to 4¢ per gal in tank car F.O.B. supplier's gate, the current average differential between gasoline and LPG at the refinery being 7¢ per gal. This is due currently to a very sharp drop in the price of LPG several months ago. Before, the differential in price was 3 to 4¢ per gal.

In the Chicago area, a recent news release indicates that propane will be supplied to a large bus operation for which 500 propane-powered buses have been ordered, for 8 to 9¢ per gal for the next two years. Prices for subsequent years are to be based on wholesale prices at the refinery.

For the Northeast, since the cost of transporting LPG by tank car from the Southwest to the New York-Philadelphia area is the same as other liquid products and averages 6 to 7¢ per gal a good estimate of the cost for LPG from the Southwest in that area is 9½¢ per gal F.O.B. the local refinery. This price could be reduced somewhat through tanker or pipeline transportation although the amount of the reduction, due to the extra handling required, might not be large. The current quotation of propane from refinery sources in the Northeast is below that estimated for LPG transported by tank car from the Southwest. The estimated differential in delivered price to the customer between propane, where available, and gasoline is approximately 3 to 4¢ per gal. Since propane in many states is taxed as a motor fuel in the same manner as gasoline, including the Federal tax of 1½¢ per gal, the total differential in price to the operator between gasoline and propane is the difference in delivered prices before taxes.

The stability of any price differential is of major importance to the operator. One supplier of refinery propane in the Northeast has expressed the opinion that the ultimate differential in price between propane and gasoline in that area will be small and should not be counted on as a principal basis for conversion of automotive equipment. Another major supplier in the East and Midwest, however, has been discussing supplying propane on a long term (three-year) contract basis at a more or less fixed differential in price from gasoline, this differential varying in the different sections of the country. This arrangement will differ with each supplier, some suppliers being unwilling to quote prices on differentials from other products except on a short term basis.

The availability of LPG varies with each area and each company. Thus, while propane is plentiful in the Southwest, the situation in the case of a number of Eastern refineries is that there is no excess of LPG for automotive use, the supply being committed to the more profitable industrial, utility, and bottled gas markets. In some cases, LPG is imported from the Southwest to augment the supply to the Eastern market. It should be mentioned that in most instances, the availability of LPG or propane is largely a matter of price, and recovery and availability of propane by refineries can be increased considerably if the price is sufficient to encourage such action. However, any such increases in price would obviously reduce the differential from gasoline and make the product less attractive to the operator.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Ways to Improve Bus

ALL bus design is necessarily a matter of compromise. A bus designed with only accessibility in mind would be a monstrosity in appearance, inconvenient and uncomfortable for passengers, and excessive in cost.

But the maintenance man feels that the manufacturer sometimes seems completely to overlook the fact that the bus unit or part that he installs only *once* in building the bus may have to be removed and reinstalled many times during the vehicle's life.

Proper accessibility, in other words, is more a matter of detail design than of major overall layout. (Satisfactory accessibility, for instance, can and has been achieved with each of the various powerplant locations which appear in current bus designs.)

Enumeration of the more offensive items of inaccessibility point up this importance of details. Listed in the order of frequency of servicing, they may be grouped as follows:

1. Accessibility for night service operations;
2. Accessibility for scheduled inspection, testing, and adjustment work;
3. Accessibility for removal of complete units;
4. Accessibility within major units themselves.

The items of accessibility which most concern bus maintenance men can well be discussed under those four headings.

Nightly Service Operations

There is much to be desired on most buses for accessibility in nightly servicing.

The oil dip stick, for example, must be removed and reinserted every night—or 3650 times during a ten-year bus life—yet, with some buses, a flashlight, a periscope, and perhaps a funnel, are needed to get the dip stick into the hole. Others have the dip stick so close to the exhaust manifold that the service man is easily burned. . . . And the dip stick itself could be improved by having a special surface to show the oil level at a quick glance.

Fuel, oil, torque converter fluid, and water fillers should be located in the same general area of the vehicle. At least, they should be on one end or one side of a given vehicle. Since most makes use the right side location, the left side should be outlawed to eliminate the necessity of duplicate servicing facilities on each side of the servicing lane. This will also eliminate time consuming and hazardous shifting of employes from one side of the service line to the other when servicing a mixed fleet.

All filler caps should be hinged and self-closing. Where small access doors must be used, they should be self-closing also, and require no latches. Where large access doors are required as with rear engine buses, these should have quick operating hand latches, and not require any type of tool or key to open.

Stretching the meaning of accessibility a little, the bus fuel tank should be more accessible to the fuel in the nozzle. To cut down on filling time, the tank should be designed to take at least 40 gal per min instead of the limit some have of only 15 or 20.

A sight gage or other quick means should be provided for checking the water level, particularly for the sake of those who use anti-freeze in their buses.

Air tank drains need the designers' attention. Draining two or three different air tanks with hard-to-reach valves is slow and messy at best. Not only is unnecessary time consumed, but the operation is often either neglected or only the most conveniently located tank is drained. If a satisfactory automatic drain valve can't be furnished, at least a handle should be conveniently located at the side of the bus for gang operation of all drains.

Although not ordinarily thought of as maintenance, cleaning is a very big item in the bus garage budget. To facilitate cleaning and sweeping, seats should be supported by a single pedestal at one end and by the wall at the other end, instead of having four legs, as many do. Foot rails, if required, should be high enough to give broom clearance. The lower end of stanchions should be attached to seat frames or wheelhouses and never to the floor. All corners of the floor and stepwells should be modified with rounded coves having a generous radius.

Since most buses have their exteriors cleaned by automatic washing machines, consideration should be given in body design to making all of the side area of the body accessible to the automatic

In this article, a leading bus fleet operator details the items of accessibility currently of most concern to bus maintenance men.

He bases his comments, not only on his own experience, but on information gathered in a survey from typical bus operating companies located from coast to coast. The 30 companies which supplied data to Whitfield include operations of all sizes, using all of the various makes of buses.

Maintenance Accessibility

EXCERPTS FROM PAPER BY

Randolph Whitfield, Georgia Power Co.

• Paper, "Accessibility for Maintenance," was presented at SAE National Transportation Meeting, New York, Oct. 17, 1950.

brushes. This means eliminating excessive offsets of doors and windows, and keeping projections such as marker lights at a minimum. Otherwise, unnecessary labor cost is required for hand scrubbing the areas missed by the rotating brushes.

The trend toward reducing the wage spread between skilled and unskilled workers makes the cost of unskilled operations such as servicing and cleaning represent a much higher percentage of total cost than before. For this reason, improvements in accessibility for nightly servicing and other unskilled operations assume a greater importance.

Inspection and Minor Repairs

This is the type of work most generally thought of in connection with accessibility.

Scheduled preventive maintenance systems of a highly developed type are in general use by bus companies. By spending more man-hours to keep adjustments right and parts clean and lubricated, road failures and major repairs are reduced and the life of parts is extended. With such a large portion of labor spent on inspection and adjustment under this system, the bus designer should give more attention to making his vehicle readily accessible for inspection work—so as to reduce the man-hours required for such servicing. And, there is the even more serious aspect of inspection or adjustment being inaccurately done, or neglected entirely on units that are not sufficiently accessible.

Operators report almost every component of the vehicle as being relatively inaccessible for inspection on one or another of the various makes or models of buses. It would be tiresome and useless to mention them all, so only a few typical examples will be named.

Of all things, the spark plugs are very inaccessible on two leading makes of postwar buses. Criticism by the operators was very strong on this point—and justly so.

On one current model bus, the distributor points can be seen only with a mirror. On another, the distributor timing must be set through a hole from inside the bus, while the flywheel marks used for timing can be seen only from a pit underneath the bus. Complaints are pretty general about the need of plainer, easier-seen marks for timing.

Cylinder head bolts can't be tightened on one bus without removing the valve rocker arms, and on another model the manifolds must be removed before tightening the cylinder head bolts.

The belts for the generator and compressor on one new model bus can be replaced only by first removing the entire fan accessory shaft. Belt adjustment, a frequent operation, should obviously be as simple and speedy as possible. Yet one builder goes to needless expense to furnish a complicated split-pulley type of adjustment that is slow and tedious to adjust, when a simple idler pulley would have done a better job.

One company had to send its whole group of new buses through its body shop to get an access door put in the body floor to permit adjusting a small but otherwise inaccessible switch.

The door engine mechanism of one manufacturer's bus can be inspected only after removing 23 body panel machine screws! Obviously, all equipment of this type should be provided with access doors, and all such access doors should have hand-operated latches to speed the job, and also to prevent marring body panels with screw driver scratches.

Oil bath air cleaners, if not properly serviced, will allow the engine to be worn out in short order because of the dust problem with rear or under-floor engine locations. Yet one new model bus has a cleaner that is so inaccessible its servicing is often skipped by mechanics.

The item that caused more criticism than any other is the windshield wiper. It frequently gives trouble, yet many manufacturers hide it in between the front paneling in such a way that getting to it is almost a major body job.

Next most frequently criticized is the fuse panel —both its inaccessible location and lack of identification as to which fuse is for what. Since fuse or circuit breaker panels not only are used in checking electrical troubles in the shop but also are often involved in road service calls, they should be conveniently located and the circuits plainly marked. On a bus model built by a major manufacturer, it is necessary to dismantle the dash panel to get to the fuses properly. On another model, groups of

fuses were located in three different places on the vehicle.

Electrical wiring on the bus, which has become so complex that it reminds one of a telephone exchange, brings many complaints. All wires should be permanently identified with tags, and the actual wiring and coding should follow the wiring diagram. Surprisingly enough, buses of the same make and model have been found to vary from each other, and all differ from the official diagram!

Brake slack adjusters require frequent adjustment in city bus service, and they received their share of complaints—not only as to location but also because of the difficulty of making the new complicated type of locking devices work properly.

There are a number of complaints on oil screens being difficult to remove for cleaning. In one design, the oil pump itself has to be taken out before the sump strainer can be removed. On a number of makes, no access plate is provided at all for cleaning the oil strainer, necessitating removal of the whole oil pan for what should be quick operation.

On at least three different recent buses, no access doors or other provision is made for servicing the blowers used for heating or ventilation. To lubricate, inspect, or make minor repairs to these heater motors, it is necessary to remove large sections of ducts or body paneling. This is a time-consuming, expensive operation, and mars the interior finish of the vehicle.

Each lube fitting must be greased 300 or 400 times during the life of a bus. Hence, those that are hard to get to cause many wasted hours. Far more serious is the fact that such fittings are passed up by some greasers, either because of the difficulty involved or because the fitting is not sufficiently visible. This can prove most expensive.

Sometimes the accessibility of such an obvious and important unit as the carburetor is overlooked. Of a recently purchased fleet, one operator says: "The carburetor and connecting linkage and lines to the governor are so located between the engine and the bulkhead that it is necessary for the mechanic to worm himself over the transmission and in back of the engine to work on them. Obviously this means waiting until the engine is cooled down, and is a very hot and dirty job even then."

Removability of Complete Units

It has long been the practice to do a large part of bus repair work at the bench instead of on the bus. When a part fails, the entire unit is removed and replaced with a complete rebuilt unit, and the vehicle is quickly returned to service. Often the various units are replaced before actual failure, on a mileage basis determined from actual records of local operating experience.

The unit change system has many advantages, including faster and better workmanship that results from having it done by a specialist under ideal working conditions in a unit overhaul shop properly equipped with special tools. It also permits using less expensive labor for the relatively unskilled job of changing the units on the vehicle. Further, it keeps the bus in the shop the least possible time.

During the life of a city bus, all of its units are changed many times, depending on the severity of the service and the durability built into the units. A carburetor for example, if changed on a 15,000 mile-basis would be removed and replaced 25 or 30 times during the life of the average city bus.

Such a unit may be accessible for inspection, but difficult to remove because of such things as insufficient wrench clearance, or being blocked by other parts when lifting out, or by poorly arranged piping or wiring connections. Hence, the design engineer should consider each part from the standpoint of both inspection and removal.

Each design should make necessary provision to insure the correct placement of any unit which requires mounting in a certain relative position with other parts. For example, many hours of labor are lost when it is found, after installing an engine, that the flywheel is bolted to the crankshaft in the wrong position, making the timing marks useless.

Another example is ignition distributors. The distributor shaft should have a coupling so indexed that the unit can be installed only in the position for proper timing. If the distributor can be removed only together with its driving gear, the expensive services of a skilled mechanic are required to get the timing correct. The same applies to injector pumps.

In this same connection, it would surprise all of us if we really knew how many batteries and how many a-c type generators were damaged by the battery being installed backward. The American Transit Association has recommended a standard of different size positive and negative terminal connections which would prevent this. It should be generally adopted. All wiring can't be provided with different size terminals to prevent wrong connections, but proper identification of wires will speed up changing of units and prevent mistakes as well.

Numerous instances involve unreasonable difficulty in removing units on various models of buses. I will mention only a few more representative cases.

Aside from windshield wipers and heater blowers being sealed up in body paneling, as mentioned, the most general complaint is on radiators. Too many other parts must be removed first, such as body panels, shutters, shutter thermostats, shrouds, fans, and even entire accessory drives. Difficult as radiators are to remove, on one make bus it is necessary to remove its radiator completely simply to replace the fan!

Some engines can't be removed without first taking off the cylinder head, while others require first removing frame members, radiators, or body panels.

On some buses, the air compressor head cannot be removed without taking out the entire compressor. Since it is general practice to unit-change the head about twice as frequently as the compressor itself, much time is wasted by this oversight in design.

To remove the generator on one bus necessitates first removing the air compressor, and, on another bus, the storage battery. The d-c type generator has grown so big and heavy that it is a hazardous thing to handle in removing. Its round shape further adds to its unwieldiness. This situation could be helped by making provision on it for attaching a sling or a handle for gripping it during removal.

One more item worth mention is the split-type rear-axle housing. Many more man-hours are required for unit changing the differential assembly with this design than with the banjo type. For this reason alone it is unpopular, aside from weaknesses such as difficulty in keeping it tightly bolted together.

Units after Removal

There are practically no complaints from transit companies regarding accessibility within the units themselves after removal. This fact points up two thoughts:

First, it proves the advantage of the unit change system of maintenance. If the unit requiring repairs can be placed on the work bench or on a stand with plenty of room and illumination, and in a comfortable position with no hot exhaust pipes or dripping dirt and grease to annoy, the most complicated "innards" can be worked on with comparative ease.

Second, it shows that the design engineers' efforts toward providing better accessibility can be concentrated on making the units on a bus convenient for minor service operations and for removal. He need not compromise the design of the units themselves to improve their accessibility for overhauling after removal, as this does not seem to be a problem in bus maintenance.

Items Related to Accessibility

One of the pet peeves of the maintenance man is the tool box full of screw drivers necessary for working on a modern bus. Formerly about four sizes of standard screw drivers would take care of most work. Now this must be multiplied at least three times to care for the addition of the Phillips-head type and the clutch-head type of screws now in use. As a result, in actual practice, the mechanic never seems to have the right screw driver at the right time. So, he ends up ruining the head of the screw and perhaps scarring up a body panel as well, by attempting to do the job with the wrong type or size of screw driver.

Improvements in screw head designs are certainly welcome. But if these changes are really to be improvements, the best type should be used throughout the bus—not a confused assortment. Since most fleets operate more than one make of bus, all bus manufacturers should get together on one type of screw head if they want to help the maintenance man.

The same complaint applies to the multiplicity of types of connections used for hydraulic, gas, oil and air tubing. The various manufacturers even use different threads for the same size and type of connections.

Then there are tow hitches. Some are located on the centerline, some on one side or the other. Some have eye connections and some pin connections, and the sizes of both vary. When all these various combinations are put together in a mixed fleet, the tow truck ends up with a sizable load of adapters and rigging to accommodate them all. The resulting waste of time in pulling in a vehicle should be eliminated by standardizing the tow connections.

While these last mentioned things are not items of accessibility in the strictest sense, they are items of design that make it difficult for the mechanic to get repair or inspection work done and in this sense they involve accessibility.

How To Improve

There is no single cure-all for poor accessibility. Of eight bus manufacturers consulted, all of them had definite procedures and checks for seeing that each new design of vehicles was satisfactory from the standpoint of accessibility. Yet new model buses are still brought out with various undesirable characteristics of accessibility. Undoubtedly a conscientious effort is made by them to avoid such mistakes, but they still occur.

Theoretically, building a pilot model should eliminate accessibility faults. This certainly helps, but it is difficult to foresee and duplicate at the factory on a pilot model the conditions and situations that will be encountered in actual service in the field.

It would help a great deal to have the field service representatives discuss directly with the design engineers the accessibility faults as they are found in the field. That would not correct the buses already in service, but should prevent the same error being made on the next design.

In view of these practical considerations, it is almost necessary that the matter of accessibility be fully taken care of in the original design drawings—a most difficult thing to accomplish. It is difficult even if the designing engineers were fully cognizant of the problems of actual maintenance that are involved, and too often they have not had the opportunity of getting actual shop maintenance experience that is so essential in this connection.

Perhaps there is no quick cure for this problem. However, a long term solution is to have all men employed to do design engineering first spend a few years as field service representatives for the company. By calling on the shops and actually working with the mechanics in this capacity they would gain invaluable practical experience on the problems of maintenance accessibility as they actually exist in the shop. Not only would they learn first-hand such things as working space and clearances required for actual servicing, but they would acquire judgment in such matters that can come only from practical experience. Above all, they will develop an appreciation of the importance of the problems so that accessibility will be kept constantly in mind and properly considered in all their design work.

The maintenance man also can do his share. He can offer constructive criticism and suggestions and make sure that such comments get to the proper people in the manufacturer's organization. In buying new buses, the maintenance man can also sell his own management on considering miles per man-hour as well as miles per gallon, and on the wise investment of paying a little more in first cost if necessary to purchase vehicles that have the plus value of good accessibility. It will pay good dividends.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Industries Exchange Boron Steel Data Throug

BORON STEELS look like the best answer yet to alloy conservation problems.

This fact has been brought home again and again at the frequent, well attended meetings of SAE's Iron and Steel Technical Committee groups, especially ISTC's Division VIII—Boron Steels. Division VIII is serving as a clearinghouse for information on use of boron additions to steel melts to achieve desired hardenability with smaller quantities of those alloying elements which are in critically short supply.

Division VIII's work, according to one Washington official, has been an important factor in putting the automotive industry at least six months ahead on investigation of boron steels. He indicated that both the National Production Administration and the military services are vitally interested in all the information turned up by the Division.

ISTC, working cooperatively with the American Iron and Steel Institute, has already approved—and AISI has published compositions for—these boron steels:

TS86B45	80B25	80B45	81B35
TS94B17	80B30	80B50	81B40
TS94B20	80B35	80B55	81B45
80B20	80B40	80B60	81B50

Already nine steel producers are putting boron steels into production, and samples for test are being made available as rapidly as possible.

Several steel consumers have been using certain boron steels successfully for considerable periods. One Division VIII member reported that 50 tons of heavy-duty countershaft production parts made from 43B17 have been in service for five years. The 43B17 was used in place of SAE 4820. During that time, two parts made from SAE 4820 failed but none of the 43B17 parts failed.

A large producer of hypoid gears has switched entirely to 94B20 and 94B17 for three sizes of hypoid gear ranging from 9 to 15 in. This producer has already used more than 4 production heats of the boron steels.

Two other manufacturers are usin 14B35, which is the boron-steel versio of SAE 1035, for fairly highly stresse bolts.

An aircraft engine manufacture disclosed at a Division VIII meetin that 43B10 (AMS 6266) is being used i production as a substitute for SA 9310 (AMS 6260). The boron steel ha been used satisfactorily in highl stressed gears, shafts, and couplings. The 43B10 tends to show greater carbon diffusion and greater decarburization, but machinability is about the same as the SAE 9310.

During World War II, large tonnages of boron steels were used for armor plate and for tank transmissions. The manufacturer who supplied these items has had 10 years of experience with boron steels.

Experimental work by both pro-

Members of Division VIII—Boron Steels

H. B. Knowlton, Chairman
International Harvester

W. G. Bischoff
Timken Roller Bearing

A. L. Boegehold
GMC Research Labs

H. Bornstein
Deere

W. J. Buechling
Copperweld Steel

W. E. Day, Jr.
Mack Mfg.

M. L. Frey
Allis-Chalmers

T. A. Frischman
Eaton Mfg.

V. E. Hense
Buick

E. L. Hollady
U. S. Army Ordnance Department

J. B. Johnson
Wright-Patterson Air Force Base

A. E. Jones
Watertown Arsenal

George Kalon
Detroit Arsenal

J. K. Killmer
Bethlehem Steel

H. W. Logan
Wisconsin Steel

J. C. Mertz
Pratt & Whitney Aircraft

J. G. Morrow
Steel Co. of Canada

G. C. Riegel
Caterpillar

R. W. Roush
Timken-Detroit Axle

D. H. Ruhnke
Republic Steel

Robert Sergeson
Rotary Electric Steel

L. E. Simon
Electro-Motive Division, GMC

E. H. Stilwill
Dodge

E. J. Tompkins
Central Steel & Wire

F. F. Vaughn
Caterpillar

L. E. Webb
Clark Equipment

S. L. Widrig
Spicer Mfg.

P. R. Wray
U. S. Steel

F. C. Young
Ford

P. K. Zimmerman
Ryerson

ISTC Div. VIII

TO spread the knowledge about use of boron in steels for the good of the entire steel and automotive industries and the military services, Chairman H. B. Knowlton urges all metallurgists working with boron steels to contribute their data to ISTC Division VIII. Information should be sent directly to

Harry B. Knowlton
Chairman, SAE ISTC Division
VIII—Boron Steels
c/o International Harvester Co.
180 North Michigan Avenue
Chicago 1, Illinois.

ducers and users has been accelerated during the past year. Four large steel companies, under AISI auspices, have been conducting extensive research on boron steels and have made melts available to their customers for experimental work on processing and for service testing parts.

Foresighted steel users have taken advantage of the experimental melts to try out boron steels as replacements for higher-alloy steels that are increasingly hard to get. Some of the replacements steel users reported to Division VIII as being under consideration are:

46B17 for SAE 4817
86B15 for SAE 4815
86B17 for SAE 4817
94B17 for SAE 4817

(These boron steel compositions have not been standardized by ISTC and AISI, although they may be if experience confirms their value.)

Metallurgists familiar with the supply situations warn that the only way to maintain production—military as well as civilian—is to learn how to use leaner-alloy steels, such as boron steels, successfully. Increased production of aircraft gas turbines is taking a huge bite out of the supply of alloying elements for other purposes. And the supply is already restricted because of high postwar demand and reduced imports.

There is even a possibility that boron may be used to substitute for manganese in shell steel, it was disclosed at one Division VIII meeting. (Manganese, as Earle Smith says in an article in this issue of SAE Journal, might conceivably have to be flown to the United States from Africa in time of war.)

At ISTC's direction, the SAE Information Service has compiled a bibliography on boron steels, which Division VIII circulated with minutes of their March 9 meeting.

15 More Disc Wheels Approved for Tractors

THREE additions to the SAE Recommended Practice on Tractor and Implement Disc Wheels have been prepared by the Tractor Technical Committee and approved by the SAE Technical Board.

To provide interchangeability in mounting between 15 and 16 in. agricultural implement wheels and tractor wheels, one addition gives dimensions for:

1. Wheel diameter of 15 in. with 2¼ in. offset, in two weights and three rim sizes—a total of four combinations.

2. Wheel diameter of 15 in. with 1⅛ in. offset, in two weights and three rim sizes—a total of four combinations.

To provide interchangeability in mounting between 15, 16, 18, and 20 in. agricultural implement wheels and tractor wheels, a second addition gives dimensions for:

1. Wheel diameter of 18 in. with 2¼ in. offset, in one weight and one rim size.

2. Wheel diameter of 18 in. with 1⅛ in. offset, in one weight and one rim size.

3. Wheel diameter of 20 in. with 2¼ in. offset, in one weight and one rim size.

4. Wheel diameter of 20 in. with 1⅛ in. offset, in one weight and one rim size.

The third addition covers a 12 in. disc wheel with smaller hub attaching elements than the 15 and 16 in. series for tractor front wheels, implements, and garden tractors. This addition to the SAE Recommended Practice provides a wheel diameter of 12 in. with 1¼in. offset in one weight and three rim sizes—a total of three combinations. Table 1 shows the tire sizes for three rim sizes.

Table 1—Maximum Tire Sizes and Loads for 12 in. Discs

Rim	Maximum Tire Size	Maximum Load, lb
12 × 3.00D	5.00-12, 2 ply	355
12 × 3.00D	4.00-12, 4 ply	635
4JA-12	5-12 2-ply	315
5JA-12	6-12 2-ply	395

Transmission Report Delivered to the Army

SAE'S "Evaluation of Automatic Hydraulic versus Conventional Transmissions for Use in Tactical Vehicles" was delivered to the Department of the Army about the middle of May. Prepared at the Army's request by the SAE Technical Board's specially appointed SAE Military Transmission Committee, the report comprised nearly 70 pages of data and recommendations.

Chairmanned by E. P. Lamb of Chrysler, the MT Committee got valuable assistance from technicians in various parts of the industry. Harold T. Youngren of Ford was Technical Board sponsor for the Committee.

Serving with Lamb on the Committee were: W. F. Benning of Willys-Overland; C. J. Bock of GMC Truck & Coach; H. E. Churchill of Studebaker; F. R. Nail of Mack; H. K. Reinoehl of International Harvester; and W. M. Walworth of Reo.

Among those who contributed importantly to the Committee's information were G. D. Giuliana, mobile equipment supervisor, The Cleveland-Cliffs Iron Co.; Charles A. Lindberg, super-

visor of truck maintenance, Oliver Iron Mining Co.; Ernest E. Eaton of Clark Equipment; D. T. Sicklesteel of Detroit Gear; E. L. Ludvigsen and T. Backus of Fuller Manufacturing; W. P. Michell and D. D. Robertson of Spicer; L. R. Buckendale of Timken-Detroit Axle; and Palmer Orr of Warner Gear.

Technical Board Approves CIM Light

FIG. 1 shows the new SAE Recommended Practice on a Sealed Lighting Unit for Construction and Industrial Machinery.

This SAE Recommended Practice was prepared jointly by the SAE Construction and Industrial Technical Committee and the SAE Lighting Technical Committee, and has just been approved by the SAE Technical Board.

This new Recommended Practice will appear in the 1951 edition of the pamphlet entitled "SAE Standards for Lighting Equipment and Photometric Tests." This edition will become available through the SAE Special Publications Department in July.

SAE's AMS Meeting Rising Defense Demands

EIGHT HUNDRED PERCENT increase in SAE Aeronautical Material Specification sales in 1951's first quarter as compared to 1950's reflects the tremendous part these SAE publications are playing in defense expansion. . . . And the second quarter increase as compared to last year is very much greater; may easily run over 1000%.

More than 271,000 AMS were distributed to industry in the January-March period this year—and April's 132,338 total was not far behind March's 137,050, the highest month.

The first quarter rise was part of a fairly steady upswing in demand for these vital specs as the defense effort moved ahead. SAE facilities for quick handling could be kept fairly well abreast of the increased daily requirements—even when an average of 3,165 per working day had to be delivered in February, 1951, as compared to the 412 per day average of February, 1950.

But when March, 1951, orders skyrocketed to 137,050 (a 6,230 per working day average), even day and night effort, extra help, and hard work couldn't prevent a log jam from developing. By the middle of April, however, despite continued increase in volume, deliveries were flowing again with reasonable celerity.

Wide areas of the industries in which SAE has members are benefiting by this full-scale availability of AMS as automotive in addition to aeronautic companies participate in subcontracting functions requiring AMS use.

New SAE Engine Test Form Replaces 1943 Rules Sheet

A NEW "Rules and Directions" sheet (Form GA) of the SAE Gasoline Engine Test Code replaces the version adopted in 1943. The revision was prepared by the SAE Engine Technical Committee and approved by the SAE Technical Board.

Chief differences between the old and new versions lies in the treatment of friction horsepower in converting observed brake horsepower to corrected brake horsepower at standard atmospheric conditions (dry air at sea level

Continued on Page 116

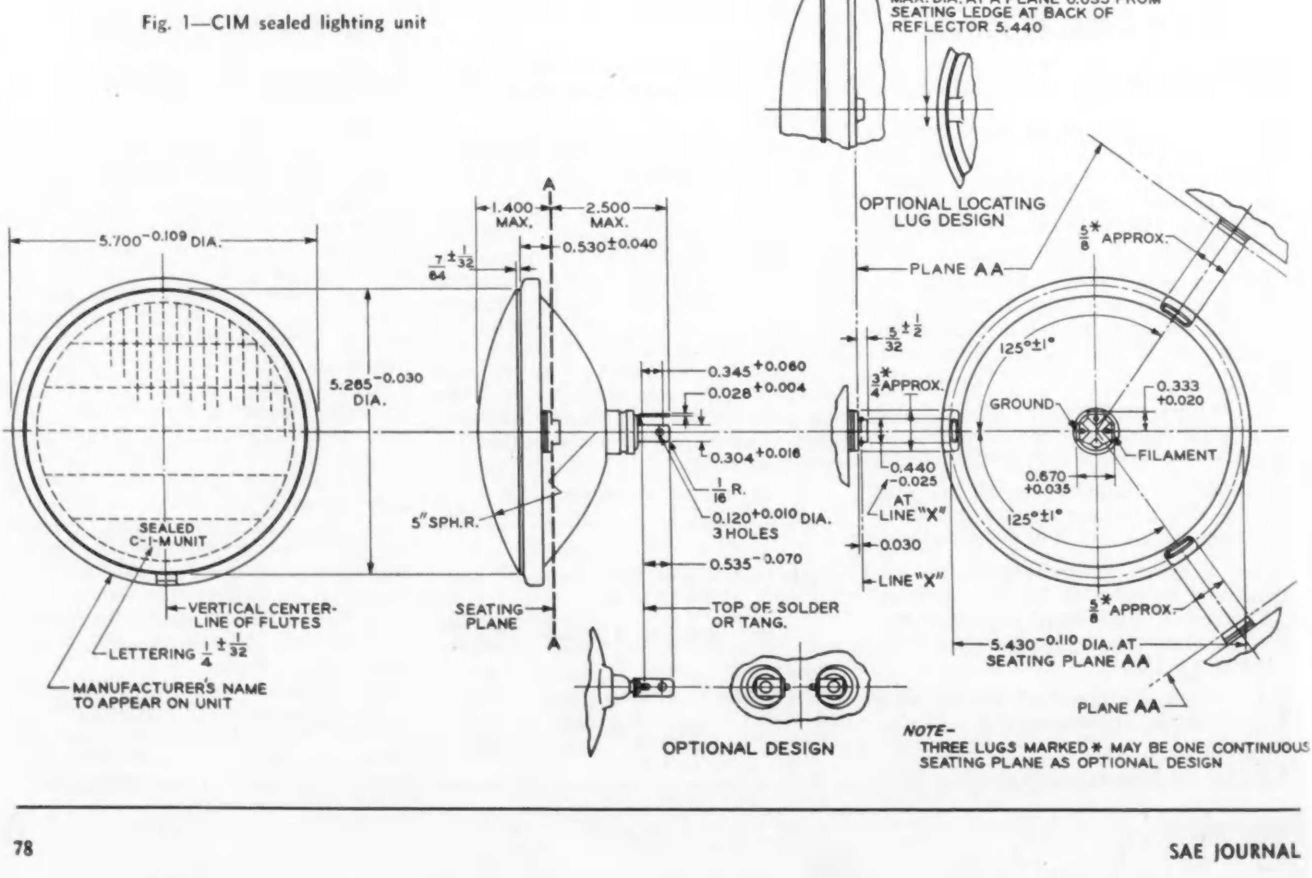


Fig. 1—CIM sealed lighting unit

Air view showing part of static exhibit on one of air strips at Idlewild

Idlewild Air Show—1951

SPECTACULAR fast passes, rolls and steep climbs marked the SAE Air Show on April 19 at the New York International (Idlewild) Airport, the second annual exhibition of latest aircraft held as the finale of the SAE National Aeronautic Meeting.

Despite a downpour during the morning and cancellation of several promised airplanes, the 500-odd members and friends basked in bright sunlight during the afternoon showing on the 300 × 6000-ft runway made available by the Port of New York Authority and its manager of the huge airport, George McSherry.

The morning was devoted to the examination of the aircraft in the static exhibition. The ships ranged in size from the Piper Super Cub to a Boeing Stratoliner, and included jet fighters and helicopters.

For the first time in the city's history, round trips from the Heliport atop the Authority's building on Manhattan's Eighth Avenue were flown to Idlewild. Passengers included SAE President Dale Roeder, Tex and Jinx McCrary, five reporters and photographers.

A 20-ft Navy Skyhook balloon was inflated and on display in the new Trans World Airline Hangar, loaned to the SAE Display and Demonstration Committee through the courtesy of Ralph S. Damon, TWA's president. Also on exhibit was a deflated 120-ft balloon of the same type. These balloons have frequently been mistaken for "flying saucers." Lunches were served in the hangar.

The afternoon's demonstration, announced by General Chairman M. G. Beard and Display Chairman R. Dixon Speas alternating at the microphone, started off with the dramatic climbing of the single-engine De Havilland Beaver, shown to the public in this country for the first time that day.

This was followed by climbing and fast passing of the De Havilland 2-engine Dove, with Peter Hadfield, assistant air attache of the British Embassy, at the controls. It is a 10-passenger ship designed primarily for feederliner service. In one of the passes, Mr. Hadfield feathered one of the two propellers as he held a steady course.

Next to be flown was the Republic F-84E Thunderjet, of the type now in combat in Korea. It made both slow and fast passes and roared off as it rapidly receded in the distance. The slow pass was made to demonstrate the jet plane's ability to furnish tactical support for ground troops.

The North American F-86 Sabre was piloted at high speeds, not for thrills but to show the spectators what was achieved from the conception to combat use of a jet fighter within the short space of 18 months. Brig.-Gen. Jacques Luis Murtin, French Air Attache, remarked, "This one must see genuinely to believe!" as he watched the performance of this airplane.

The Lockheed F-94, with a crew of two, demonstrated the prowess of one of the latest jets now in production.

The U. S. Coast Guard demonstrated the maneuverability of one of its Sikorsky rescue helicopters—of the type now being used effectively in Korea, and the City Police Force demonstrated pickup and landing operations with one of its Bell 47 helicopters.

A passenger car was loaded on a Fairchild C-119, which then flew away to show how the "workhorse of the Korean campaign" works.

A Convair 40-passenger airliner made a pass over the runway and the event closed as the 11-bus convoy returned to the city.

See following pages→

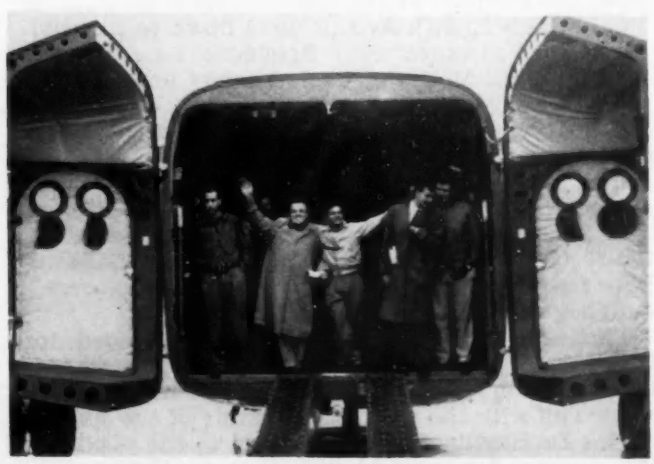
Idlewild Air Show—1951

Continued

Noted TV team, Tex McCrary and Jinx Falkenberg, who flew to the Exhibit by Sikorsky helicopter, are shown here inspecting the bomb racks of the F-84E. With them are (left) J. A. C. Warner, secretary and general manager of the SAE, and (right) SAE President Dale Roeder

Close inspection of the exhaust end of one of the jet engines on display at the Air Show

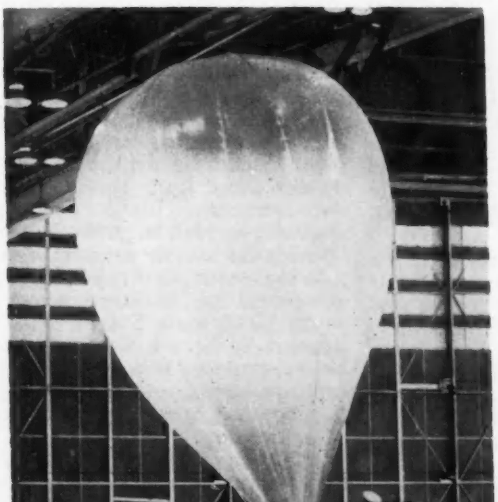
Inspection of the U. S. Coast Guard Sikorsky helicopter (above) and (below) this helicopter demonstrating how it can hover while a rope is lowered to pick up a man and lift him up into the cockpit



Fairchild C-119 (Packet) opened to show how vehicles can easily be driven into its widened fuselage. The Packet can be used as troop transport, litter carrier, or as a heavy cargo plane

Dixon Speas, chairman of the Idlewild Display and Demonstration Committee talks to (right) M. G. Beard, chairman of the General Committee that aranged the SAE National Aeronautic Meeting

During the morning inspection period, many who went on the trip to Idlewild were fascinated by the cockpit of the North American F-86 (Sabre)



Inflated 20-ft Navy Skyhook balloon next to deflated 120-ft balloon of same type. These are the kind of balloons that have frequently been mistaken for "flying saucers"

Among those who enjoyed the Idlewild Air Show were Brig.-Gen. Jacques Luis Murtin, French Air Attaché, and Jim Redding, director of aeronautics, Research and Development Board

Boeing Stratocruiser was largest plane on exhibit. In foreground are some of about 500 members and guests who watched afternoon's demonstrations by jet planes, helicopters, and other aircraft

Bell helicopter landing on the new Heliport atop the New York Port of Authority Building in Manhattan. For the first time, round trips were flown between the Heliport and Idlewild, where the SAE Air Show was in progress

Military-Industry Aims the Same; SAE-CIMTC Aids Army Engineers

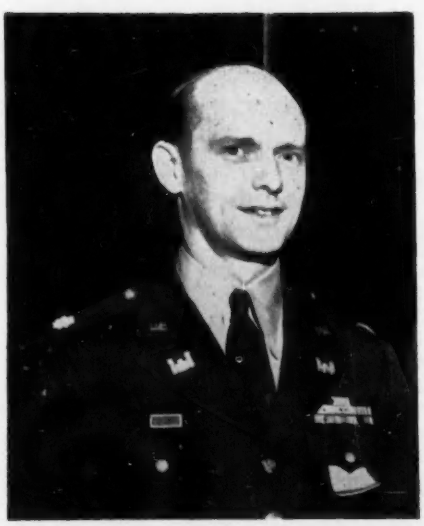
By Lt.-Col. D. C. Hammond, Corps of Engineers, U. S. Army

• The paper from which these excerpts were taken was presented at the Central Illinois Section Earthmoving Conference at Peoria, Ill., April 10, 1951. It was titled: "Earthmoving Industry and the Corps of Engineers in War and Peace."

ONE of the major problems the Corps of Engineers is engaged in trying to solve is the necessity of providing airborne equipment. This will be equipment which can be transported by air without disassembly, to assist in the establishment of forward air strips.

A second requirement is for means of emergency reconditioning of unstable areas to permit the passage of divisional equipment. Divisional equipment is, as the name implies, for use in forward combat areas, but in modern warfare this does not mean small light equipment. It includes heavy artillery and armor and a large volume of heavy truck traffic. These two led to the establishment of the requirement for all construction equipment to provide increased capacity, mobility, maneuverability, simplified maintenance, ease of operation, and multi-utility, where feasible. Multi-utility is a particularly important requirement.

First consideration has been given to airborne equipment. It is necessary to provide construction equipment which weighs not more than 16,000 lb in operating condition, and with maximum bulk approximately 8 × 8 × 40 ft. This is in consonance with the limitations of the assault aircraft and gliders. Much progress has been made in this field due to the very excellent efforts of the members of the earthmoving industry.



Lt.-Col. D. C. Hammond, Engineering Research and Development Division, Corps of Engineers, who spoke at SAE Central Illinois' 1951 Earthmoving Industry Conference

In addition to the problem of the construction of airfields as part of airborne operations, there is the more general and perhaps more pressing problem of providing forward airfields to support ground combat operations. Present-day airplanes have much heavier wheel loadings and higher tire pressures than those used in World War II. The solution to this problem may lie not entirely with improvement in construction equipment and techniques but may necessitate changes in the airplane as well. The provision of pneumatic track-type landing gear, for example.

One of the greatest deficiencies in the equipment line during World War II lay in the wide variety of makes and models of equipment designed to perform the same function. Thus, very frequently we had sufficient and adequate equipment and large stocks of spare parts, but the spare parts did not fit the deadlined equipment. Several attempts are now being made to solve this problem without resorting to special military design items of equipment.

The SAE is working on several lines of endeavor designed to improve this situation. Subcommittees of the Construction and Industrial Machinery Technical Committee are working on means of achieving interchangeability of parts and attachments on such things as the electrical equipment, power controls, cutting edges, tires and rims, and so forth.

SAE on its own had undertaken this problem which led to the liaison established by the Corps of Engineers in November 1949 with the CIMTC. The activities of your committee since that date have been of great value to the Corps of Engineers.

One effect is already being felt in changes made to Corps of Engineers specifications in conformity with SAE standardization actions.

In addition, specific projects are being undertaken by the Corps of Engineers through participation in Munitions Board standardization committees to achieve this goal for industrial engines and crane and shovel attachments. We have hopes of achieving a high degree of interchangeability in these fields without major changes in basic tooling of industry.

It is evident that such a program can be successfully culminated only by the closest cooperation and coordination between the Corps of Engineers and industry. It is our firm policy to conduct such programs in accord with a recognition of this necessity.

You probably will be interested in some of the requirements which we foresee for new types of construction equipment not now available commercially. Requirements for increasing speed, mobility, and maneuverability have led to the development of rubber-tired equipment. This is a commercial trend as well as a military trend. Additional requirements for multi-purpose utility necessitate the development of rubber-tired and crawler prime movers which are interchangeable for use with scrapers, dump trailers, compaction equipment, and machinery trailers. In connection with machinery trailers, our desire is to get away from their use entirely. But recognizing that this may not be possible, we plan to minimize their use.

Some investigation has been made into the feasibility of modifying crawler equipment to provide convoy speeds of 25 to 30 mph, but at present this appears to be a too major change to be warranted. It would be strictly a military design and therefore difficult to procure in quantities needed in time of emergency.

Although construction operations demand crawler equipment under adverse soil conditions, the mobility and maneuverability of wheeled equipment capable also of moving from job to job under its own power is considered a supplemental must. This leaves only the question of what proportion of rubber-tired and crawler equipment to provide.

Among the developments that we foresee a need for in the immediate future is the heavy-duty, rubber-tired tractor dozer and prime mover for construction equipment. It is believed that a tractor of 30,000 to 35,000 lb drawbar pull, capable of a certain degree of dozer operation and application as a tow tractor for scrapers, dump crawlers, compaction equipment, and other equipment is essential. Operating speeds up to 25 mph and convoy speeds of 35 mph are needed.

Additional proposed investigations include further development of airborne equipment in the 16,000 lb class, equipment for amphibious and arctic operations and increased capacity on items such as 2- to 4-yd front loaders, 20-ton dump trailers and 18- to 25-yd scrapers.

I would like to reiterate our appreci-

ation for the vast efforts and cooperation of the earthmoving industry, the Society of Automotive Engineers, and our continuing dependence on such efforts for the solution of our remaining problems and new ones not now foreseen, which may be expected to arise. The aims of SAE and the earthmoving industry and our aims and interests are identical.

Housewives in Lead Among Air Travelers

Based on paper by

RALPH S. DAMON

Trans World Airline

PASSPORT figures show housewives to be the greatest air travelers of all. Skilled laborers are usually second on the list for the year and often hold their rank even during the peak travel seasons. There are cobblers, steel workers, and common laborers who have been to Europe as many times as our social leaders.

It used to be thought that a large number of air travelers were first-generation immigrants going back to the old country for a visit. But at the close of last year, passport applications by native born citizens showed a rise of 20% over the previous year, while applications from naturalized citizens decreased a little more than 2%.

Engineers are a traveled group, but they rank only eleventh. They come after such groups as skilled laborers, secretaries, teachers, executives, persons claiming no occupation, common laborers, retired people, and miscellaneous. The traveling salesman, the one man you would expect to see high up on the list, ranks only thirteenth. (Paper "Freedom in Flight," was presented at SAE Baltimore Section, April 12, 1951.)

Anti-Friction Bearings In Automotive Use

Based on paper by

R. M. RIBLET

Timken Roller Bearing Co.

POINTING out that the automotive industry is the largest user of anti-friction bearings and estimating that approximately 200,000,000 such bearings where used in 1950, the author presented a series of slides to show the basic principles of Timken roller bearings and typical applications of the tapered roller, ball, cylindrical roller, needle, spherangular, self-aligning, roller and ball, ball and tapered roller thrust, and many other special types.

(Paper "Timken Roller Bearings in Automotive Applications," was presented at SAE British Columbia Section, December, 1950.)

CALENDAR

British Columbia—June 11

Hotel Georgia; dinner 6:30 p.m. Annual meeting and election of officers.

Cincinnati—June 19

Summit Hills Country Club, Dudley Pike near Erlanger, Ky. Dinner; golf, horse shoes, baseball.

Cleveland—June 22

Pine Ridge Country Club. Annual golf outing and dinner.

Milwaukee—June 16

Tripoli Country Club; dinner 6:30 p.m. Ladies Night.

New England—June 19

Marlboro Country Club; dinner 6:45 p.m. Outing, entertainment showing of new and old foreign cars. Golf, sports.

Northern-California—June 13

Chukker Restaurant, San Matro; dinner 7:00 p.m. Aviation Meeting. Field trip of United Air Lines maintenance base, San Francisco Airport, starting 4:00 p.m. A paper will be given following the dinner, subject not yet selected.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
	1951	
SUMMER	June 3-8	French Lick Springs Hotel, French Lick, Ind.
WEST COAST	Aug. 13-15	Olympic, Seattle, Wash.
TRACTOR and PRODUCTION FORUM	Sept. 10-13	Schroeder, Milwaukee
AERONAUTIC, PRODUCTION FORUM, and Display	Oct. 3-6	Biltmore, Los Angeles
TRANSPORTATION	Oct. 29-31	Knickerbocker, Chicago
DIESEL ENGINE	Oct. 29-30	Drake, Chicago
FUELS and LUBRICANTS	Oct. 31-Nov. 1	Drake, Chicago
	1952	
ANNUAL	Jan. 14-18	Book-Cadillac, Detroit

W. C. NEWBERG has been appointed vice-president and general manager of Dodge Division, Chrysler Corp. Newberg was formerly president of Chrysler's Airtemp Division.

A. P. FONTAINE has been elected a vice-president and general manager of Consolidated Vultee Aircraft Corp., San Diego, Calif. After 21 years' experience in the aircraft industry, Fontaine has returned to the company with which he was associated between 1939 and 1945.

WILLIAM A. McKINLEY has been elected executive vice-president of The Midland Steel Products Co., Detroit. McKinley has been associated with Midland Steel for more than 26 years, and recently has headed Midland's sales and engneering departments.

About

C. W. FREDERICK, who did product engineering on jet engines for Chevrolet Motor Division, GMC, in World War II, has been made chief product engineer of the company's Aviation Engine Division, Tonawanda, N. Y. Frederick has been with General Motors 25 years, starting as a mechanical engineer in the Research Laboratories. Since 1947 he has been at the central office, first as a truck engineer, and since 1949 as staff engineer in charge of all chassis design.

JAMES M. CRAWFORD, SAE President in 1945, retired June 1 from General Motors Corp., where he has been a vice-president since 1947. His plans for the immediate future are "to take a good rest."

He joined General Motors in 1927 as assistant chief engineer of Chevrolet and became chief engineer in 1929. Then in 1945 he was made executive assistant to the vice-president in charge of engineering for the Corporation.

During the last two years, Crawford has been very active in the Munitions Board Industry Advisory Committee for Internal Combustion Engines dealing with the standardization program for such engines. His work brought a recent commendation from a high government official, who wrote: "Certainly we recognize the fact that you evolved and took the leadership in shaping up the plan which looks so promising at this time—and which gives every indication of success."

He is retiring also as chairman of the Engineering Advisory Committee of the Automobile Manufacturers Association, which he has headed since October, 1949.

Crawford's varied services to SAE have been marked by the same combination of aggressive attack on problems and achievement of concrete results which characterized his industrial success.

He played a major part in organizing the SAE Technical Board following World War II, during which he had been one of SAE War Engineering Board's most active members. He was the second chairman of the SAE Technical Board after its organization in 1946.

As president of the Coordinating Research Council, following his SAE presidency, he guided that SAE-API-sustained group through an important, constructive reorganization of its administrative structure.

Earlier, during World War II, he had served CRC as chairman of its Coordinating Equipment Research Committee and on its Board of Directors. During the war, also, he served as chairman of the Engineering Policy Committee of the Central Aircraft Council.

Prior to becoming president of SAE, Crawford had served the Society as vice-president for Passenger Car Engineering and as a Councilor.

SAE Members

V. A. CROSBY of Climax Molybdenum Co. was awarded the 1951 John A. Penton Gold Medal for "outstanding service to the American Foundrymen's Society and his contributions to the

V. A. Crosby

dissemination of information relating to ferrous foundry metallurgy." Presentation was made April 23 at the annual AFS banquet in Buffalo. Crosby has actively served SAE technical committees and Activities committees—as a member of the Iron & Steel Technical Committee, as chairman or vice-chairman of various ISTC panels and divisions, and as vice-chairman of the Engineering Materials Activity and chairman of its membership committee.

CHARLES F. KETTERING, Research Laboratories Division, GMC, was the principal speaker at a University of Cincinnati program, April 18, marking the 45th anniversary of the founding of the University's noted cooperative system of technological education. The Kettering Laboratory of Applied Physiology of the College of Medicine, a national center for research aimed at clearing up health hazards arising out of activities and materials of modern industry, is named in Kettering's honor.

DR. HENRY J. E. REID, director of Langley Aeronautical Laboratory, was honored for 30 years of service with the National Advisory Committee for Aeronautics at a smorgasbord dinner, April 30, attended by 200 of his long-time associates. **DR. EDWARD R. SHARP,** director of the Lewis Flight Propulsion Laboratory, was master of ceremonies.

JOHN V. DUNN, vice-president of Wheels, Inc., New York City, was appointed manager of the New York branch operation. Dunn has served with the corporation for a period of 27 years, during which time he has rendered service in office, warehouse, and field service activity.

The following SAE members have been elected officers of the Canadian Chamber of Commerce at the annual meeting of the Association. **D. C. GASKIN,** vice-president and general manager of the Studebaker Corp. of Canada, Ltd. — vice-president; **J. L. STEWART**—general manager; **F. R. HAZELTON**—secretary. The board of directors of the Association includes: **E. J. COSFORD,** Canadian Car & Foundry Co., Ltd.; **W. A. WECKER,** General Motors of Canada, Ltd.; **D. C. GASKIN,** the Studebaker Corp. of Canada, Ltd.; **L. M. HART,** the White Motor Co. of Canada, Ltd.

ALLISON L. BAYLES has been appointed vice-president of engineering of the Scaife Co., Oakmont, Pa. In this capacity he will be in charge of all phases of plant engineering, as well as product design and engineering. Scaife Co. produces containers and pressure vessels for liquids, air and gases.

G. WAINE THOMAS has been elected a vice-president of Continental Motors Corp., Muskegon, Mich. He will continue his duties as chief engineer of the Automotive Division.

J. J. ROZNER, formerly chief engineer and works manager, has been elected vice-president in charge of operations of the Aetna Ball and Roller Bearing Co., Chicago. Rozner has been with Aetna since 1928. In his new position he will direct all manufacturing, engineering, inspection, quality control and development activities.

F. ALEX NASON has been promoted from vice-president in charge of sales to first vice-president and director of marketing of The Lubrizol Corp., Cleveland. He is one of the five men who founded Lubrizol in 1928.

GEORGE W. MARSHALL, JR., has been elected vice-president of Raybestos-Manhattan, Inc., Passaic, N. J. Marshall, who has been sales manager of the company's Asbestos Products Division since 1947, will continue to direct sales activities on asbestos products at the Raybestos-Manhattan Manheim, Pa., plant.

CHARLES C. SONS has been appointed acting eastern service manager of the Cummins Engine Co., Inc., Columbus, Ind. Sons has been with Cummins since 1947, when he joined the Cummins Research Laboratory staff as a field engineer.

FRED T. ROBERTS has been made manager of truck, bus and trailer wheel sales of The Budd Co., Philadelphia. A veteran of 25 years with Budd, he has been in the company's Wheel Sales Division since 1928.

In Washington . . . .

Courtney Johnson

Robert Cass

COURTNEY JOHNSON, left, assistant to the chairman of the board, Studebaker Corp., has been appointed director of the recently inaugurated Motor Vehicle Division of the National Production Administration. **ROBERT CASS,** right, White Motor Co.'s assistant general sales manager, is deputy director. Both men are on leave from their companies, Cass having gone to Washington a few weeks earlier as chief of an automotive branch of a Transportation Equipment Division —whose functions are now a part of the Motor Vehicle Division's work.

HARRY E. ERWIN, who, prior to this, was service engineer with Chrysler Corp., Detroit, is now service representative with the Detroit Diesel Engine Division, GMC, in that same city. His new position entails the instruction of personnel connected with the operation and service of diesel engines.

J. L. KEESHIN is presently president of C. A. Conklin Truck Line, Inc., and Truck-Rail Terminals, Inc., both of Chicago. Prior to this, he was president of Keeshin Freight Lines, Inc., also of that same city.

MERLE F. VALADE has recently been transferred from the Rouge Plant of Ford Motor Co. to the Aircraft Engine Division in Chicago. He is assistant manager of chemical and metallurgical engineering.

W. E. MEYER has been promoted from associate professor of engineering research to professor of engineering research at the Engineering Experiment Station of The Pennsylvania State College.

PAUL H. KLEINMAN is presently a production process engineer with Ford Motor Co., Engine & Foundry Division, Dearborn, Mich. Prior to this, he was employed by General Motors Corp. as a methods engineer in the Ternstedt Mfg. Division, Detroit.

CYRIL WILSON, formerly a sales engineer with Willys-Overland Motors, Inc., Toledo, Ohio, is now a staff engineer with that same company.

JOSEPH GESCHELIN, vice-chairman, National Production Activity Committee, was a member of an industry panel of editors on a special program arranged by the Eastern Industrial Advertisers in Philadelphia on May 3. His subject was the economic outlook for the automotive industries.

Geschelin has also been appointed a member of the Advisory Committee of Technical Committee K of the American Society for Testing Materials. At the same time he was also made a member of Technical Committee K. This Committee is concerned with standardization work in connection with the utilization of cutting fluids.

JUDSON H. PICKUP, who was formerly development and standards engineer for Pan American Airways, Inc., is now with Champion Spark Plug Co. as sales engineer for the Northern California district.

CHARLES H. MARTENS is now with the USNR Bureau of Aeronautics, Navy Department, Washington, D. C., holding the title of lieutenant-commander. Prior to this, he was an engineer working on guided missile development at Wright-Patterson Air Force Base, Dayton, Ohio.

MYRON B. GORDON, formerly an officer and director of Curtiss-Wright Corp., Wright Aeronautical Corp., and Fairchild Engine and Airplane Corp., has been elected to the board of directors of Air Associates, Inc., Teterboro, N. J. Most of Gordon's 23 years in the aviation industry have been in general management and administrative capacities. Gordon has recently been acting as management consultant at Air Associates.

RICHARD C. KORFF, formerly with Sterling Motor Truck Co., Chicago, is now on active duty with the U. S. Air Force. He is a sergeant with the 108 Bomb Squad (L) in Chicago.

IGOR SIKORSKY has been given the top award of the American Helicopter Society, the Dr. Alexander Klemin Award. Sikorsky received the honor which includes both a certificate and a plaque at the Honors Night Banquet during the Seventh Annual Forum of the Society in Washington, D. C., on April 26. As the first recipient of the Dr. Alexander Klemin Award, established by **FRANK N. PIASECKI**, founder and board chairman of Piasecki Helicopter Corp., Morton, Pa., Sikorsky's name is on the top of the list of other names to follow on the permanent plaque which has inscribed as the reason for the award, "For notable achievement in the advancement of rotary wing aeronautics."

A. J. BENT has been appointed director of the Industrial Products Division, Westinghouse Air Brake Co., Wilmerding, Pa. Bent, formerly field sales manager of the division, will direct manufacturing, sales, and marketing activities of the company's air compressors and pneumatic controls in the automotive, marine, oil rig, aircraft, and industrial fields.

JOHN J. BERGWELL, who graduated from Cal-Aero Technological Institute in January, 1950, has returned to the West Coast and is now employed as an engineering draftsman with North American Aviation, Inc., Los Angeles. Since his graduation he has been employed by the Standard Conveyor Co., St. Paul, Minn.

JOHN P. HOBART, formerly a senior project engineer with Chevrolet Motor Division, GMC, Detroit, is now a quality control project engineer with Chevrolet Aviation Engine Division, Tonawanda, N. Y.

L. E. LIGHTON, vice-president of engineering, Electric Storage Battery Co., Philadelphia, has announced plans for a new three-story engineering building. It will be 52 ft wide and 421 ft long. One of its features will be a museum of Exide products, where company engineers may conveniently refer to past developments as they seek solutions to new technical problems.

SAE Father and Son

R. A. SCHAKEL, right, manager of the Engine Drive Division of the Diamond Chain Co., Indianapolis, Ind., is shown with his son **ENSIGN R. A. SCHAKEL, JR.**, left, who is stationed aboard the U. S. S. Leyte. Schakel was chairman of the SAE Indiana Section in 1949. Ensign Schakel served six months off the coast of Korea on the aircraft carrier Leyte, which is now docked at Norfolk, Va.

H. J. HOWERTH, for the past 15 years in charge of car factory service department activities for the Alemite Division of Stewart-Warner Corp., Chicago, has been named manager of the Detroit branch office of the company.

GEORGE R. OLIVER, formerly manager of distribution, GMC Truck & Coach Division, Pontiac, Mich., has been transferred to the Government Sales Section of General Motors Corp. He will assist in handling the increased responsibilities of this activity under the defense mobilization program.

JAMES H. RICHARDS, former owner of Fray Machine Tool Co., Fray Tool & Reamer Co., Frayco Electric Motor Co., and Richards Machine Tool Co., all of Glendale, Calif., has been engaged as consulting engineer by Paul-White-Carnahan Investment Brokers of Burbank, Calif.

STUDENTS ENTER INDUSTRY

H. OWEN MOSES (University of British Columbia '51) to Canadian Industries, Ltd., Toronto, Ont.

ALVIN P. FENTON (University of British Columbia '51) to Kohler Co., Kohler, Wis.

CARL R. NELSON (Washington State College '51) to Boeing Airplane Co., Seattle, Wash.

DONALD B. HUMMEL (The Pennsylvania State College '51) to Armstrong Cork Co., Lancaster, Pa.

DALE E. WOOMERT (The Pennsylvania State College '51) to Sperry Gyroscope Co., Great Neck, N. Y.

HUGHES J. DUPREZ (Indiana Technical College '51) to Fairchild Engine & Airplane Co., New York.

W. R. OSBAN (Indiana Technical College '51) to Corning Glass Co., Corning, N. Y.

JOHN N. WRIGHT (West Coast University) to General Electric Co., Schenectady, N. Y.

HARRY B. STUCKY (University of Michigan '50) to Fram Corp., Dexter, Mich.

RICHARD C. MILLER (Lehigh University '51) to International Business Machines Corp., Poughkeepsie, N. Y.

FRED W. BOWDITCH (Purdue University '51) to GMC Research Laboratories Division, Detroit.

HERBERT H. GARTEN (College of the City of New York '51) to Reed Research Inc., Washington, D. C.

GEORGE H. BENEDICT (Rensselaer Polytechnic Institute '51) to Caterpillar Tractor Co., Peoria, Ill.

ATMA B. FLOYD, JR., (A & M College of Texas '50) to Chance Vought Aircraft Division, Dallas, Texas.

RICHARD J. VICKERS (Northrop Aeronautical Institute '51) to Northrop Aircraft, Inc., Hawthorne, Calif.

WILBUR E. DOWNING (University of Massachusetts) to Rodney Hunt Machine Co., Orange, Mass.

ROBERT G. Mac EWAN (University of Michigan '50) to Douglas Aircraft Co., Santa Monica, Calif.

ROBERT B. HAYES (University of Minnesota '50) to Consolidated Vultee Aircraft Corp., San Diego.

ROBERT T. GAUGER (Purdue University '50) to General Foundries, Milwaukee, Wis.

JOSEPH MATTHEW LATONIS (Tri-State College) to Sperti Faraday, Inc., Adrian, Mich.

ANTHONY SCOTCH (Aeronautical University) to Consolidated Vultee Aircraft Corp., San Diego, Calif.

JAMES M. WALTER (University of Colorado '50) to Lockheed Aircraft Corp., Burbank, Calif.

ROBERT M. MOORE (Northrop Aeronautical Institute '50) to North American Aviation, Inc., Los Angeles.

HENRY A. RAWLES, JR., (Parks College '50) to Remmert-Werner, Inc., St. Louis.

DWIGHT KINNEY (California State Polytechnic College) to Northrop Aircraft, Inc., Hawthorne, Calif.

BILLY J. CUNNINGHAM (A & M College of Texas '51) to Consolidated Aircraft Corp., Ft. Worth, Texas.

CHARLES JACKSON (A & M College of Texas '51) to Monsanto Chemical Co., Texas City, Texas.

EDWARD ADAMS (Aeronautical University of Chicago '51) to North American Aviation, Inc., Los Angeles.

GENE E. MENTZER (Tri-State College '51) to Link Aviation, Inc., Binghamton, N. Y.

WALTER J. FRISCH (University of Wisconsin '51) to Four Wheel Drive Auto Co., Clintonville, Wis.

DELMAR L. BOECK (Tri-State College '50) to Stewart Warner Corp., Indianapolis.

HENRY C. JAWOR (Indiana Technical College '51) to Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.

EDGAR C. FEATHERINGILL, II, (Purdue University '51) to Socony-Vacuum Oil Co., Indianapolis.

PHILLIP J. BERGMANN, JR., (Indiana Technical College '49) to McDonnell Aircraft Corp., St. Louis.

DEWEY A. SHERAR (University of Southern California '50) to North American Aviation, Inc., Los Angeles.

CHRISTOPHER C. RACHAL, JR., (Northrop Aeronautical Institute '49) to McDonnell Aircraft Corp., St. Louis.

EDWARD F. COLE, JR., (University of Connecticut '50) to Pratt & Whitney Aircraft Division, East Hartford, Conn.

FRANK LINDY BUSCARELLO (University of Michigan '51) to Continental Aviation & Engineering Corp., Detroit.

CHARLES J. KREMER (University of Colorado '50) to Ogden Engineering Co., Chicago.

HAROLD CONSTANTINE PSILLAS (University of Oklahoma '51) to North American Aviation, Inc., Los Angeles.

RUSSELL C. DAHL (University of Illinois '51) to Josly Mfg. & Supply Co., Chicago.

FRANK P. KULESZ (Academy of Aeronautics '51) to United Air Lines, Inc., New York.

JACK WILLIS (Rhode Island State College '51) to General Electric Co., Pittsfield, Mass.

JOHN C. CONZETT (Massachusetts Institute of Technology '51) to Goodyear Aircraft Corp., Akron.

JAMES HUNTLEY HERD (University of Buffalo '50) to Naval Ordnance Laboratory, Silver Springs, Md.

OBITUARY

JOHN R. CAUTLEY

John R. Cautley passed away April 24 at the Homelawn Mineral Springs sanitarium at Martinsville, Ind. He was 67 years old.

Born in Richmond, Va., Sept. 28, 1883, he was educated in public and private schools in the United States, England, Italy and Switzerland. He was a graduate of the engineering school at Cornell University, where he taught engineering for two years. Early in his engineering career he was affiliated with Hans Renold, Ltd. and the Wright-Martin Aircraft Corp. before becoming connected with the Perrot Brake Co., South Bend, Ind., in 1923. Cautley was vice-president and a member of the board of directors of that company when it became the Bendix Brakes plant. He was staff engineer with the Bendix Products Division, Bendix Aviation Corp. at the time of his death.

From 1926 until 1946 Cautley was in charge of engineering sales and service of the aircraft landing gear department of the Bendix plant. It was this department that developed the modern airplane wheel and brake, the pneumatic landing gear shock struts and auxiliary equipment. Since 1946 he has been doing research and development, mainly on aircraft landing gear. He had been an SAE member for 39 years.

SAE Section Meetings

Telephone Movies Highlight April Meeting

• Kansas City Section
R. W. Laing, Field Editor

April 10—An interesting discussion of the Southwestern Bell Telephone System's fleet truck system was conducted by **Willard Hixson,** supply supervisor of the Kansas territory.

Following the discussion two movies of the Bell Telephone Laboratories development programs were shown. The first movie "Telephone's Screen Review, No. 7" showed the construction of the Western Electric Plant at Kearney, N. J., the development of new telephone equipment and its testing by the public, and then the development of television.

The second movie, "Echoes of Radar & Sonar In War & Peace," showed the development of sonar and radar equipment. Included in the movie were several actual wartime shots showing the effectiveness of these developments.

An added feature was, "And Then There Were Four," a movie stressing safety in driving.

Section Meeting Hears Prize Papers

• Spokane-Intermountain Section
G. W. Shields, Field Editor

University of Idaho took first and third prizes, Washington State College second prize in Spokane-Intermountain Section's first Student Paper Award Contest held April 20 at a Section meeting in Spokane.

First Prize Winner Carlton C. McMullin won with his paper on "Combustion Characteristics of the New Chrysler V-8." James Thompson got second prize with "Torsional Spring Suspension for Heavy Trucks"—and Joffre Myers took third with "Design of Cars Used in the Lake Muroc, Calif., Time Trials."

First prize was $25; second, $20.

The papers made a fine meeting, in the opinion of the Section members, and the project's success probably means its continuance in future years.

Three Student Branches Guests of Cleveland Section

• Cleveland Section
Wilson B. Fiske, Field Editor

April 23—Cleveland Section was host to three SAE Student Branches at the annual banquet in the ballroom of Wade Park Manor. Guests were members of the Student chapters of Fenn College, Case Institute of Technology, and General Motors Institute. Student Committee Chairman A. D. Gilchrist presided, Guest Speaker **Dr. Harry D. Osborn, Jr.,** technical director of the Ohio Crankshaft Co., discussed the role of the young engineer.

Osborn pointed to the engineering achievements of the past as a challenge to the young engineers who will be responsible for the achievements of the future. He gave the engineering profession much of the credit for the present high standards of living in this country because of its contribution toward producing more goods for more people at lower cost.

The industrial revolution in this country is continuous, he said, because we are always endeavoring to do a better job in producing more and better products for less money. Accomplishments of the past, both in machines and in production processes, were well brought out with the use of slide film illustrations. Automatic devices, plastic materials, and other examples were offered of the great strides made in the past 10 years or so.

Speaker Dr. Harry B. Osborn, Jr. (left) with Student Committee Chairman A. D. Gilchrist at Cleveland Section's annual student banquet

Officers of the Case Institute Student Branch (left to right): Vice-Chairman Howard L. White, Secretary-Treasurer Clifford C. Crabbs, and Chairman Robert L. Broderick

Fenn College Student Branch officers pictured at the banquet. Left to right: Treasurer Albert Fischer, Chairman Earl Cummings, Secretary John A. Ford, and Vice-Chairman Antonio Salvaggio

Details Five Factors In Engine Performance

• Philadelphia Section

M. A. Hutelmyer, Field Editor

April 11—"Satisfactory performance of engines in service is dependent upon five factors," said **Carl W. Georgi**, quoting from the SAE Handbook. These are:

1. Operating conditions
2. Maintenance
3. Engine Design
4. Fuel
5. Lubricating oil

Georgi, who is technical director, research laboratories, Quaker City Oil Refining Co., and current SAE vice-president for Fuels and Lubricants, used this statement as the basis for a paper on "Additive Oils versus Engine Design and Operating Conditions."

High-additive, super-detergent oils have received so much publicity in recent months that there is an all-too-popular idea that additives and detergency are the answer to all engine lubrication problems, and that the only problem is to find the oil with the highest additive content.

The important but often-overlooked fact is that motor oil is only one factor involved with engine lubrication and performance, and there are the four other highly important factors which can either work with the oil or against it. When too many of these other factors are working against the oil, engine performance and lubrication troubles can easily occur, regardless of high-additive oils and super-detergency.

After this introduction, Georgi proceeded to analyze the various conditions and limitations found in each of the four factors which could work either with or against the oil.

1. Operating conditions: The super-detergent oils are doing a marvelous job in diesel engines; in fact, without the present detergent oils it would not be possible to operate the modern diesel. In gas engines they are doing an outstanding job when the motors are run at peak speed and load, but in light-duty stop-and-go operation, where the motor is operating "cold," the performance has not been outstanding. This is due, mainly, to the fact that the oil, in addition to its function as a lubricating and cooling agent, is also acting as a "garbage collector" of all the blow-by products cast off by the motor. Factors such as fuel dilution, water contamination, solid contamination, insoluble resins and fuels of poor burning quality, which are aggravated by cold motor operation, all work against the lubricating oil.

2. Maintenance. To illustrate the importance of maintenance, Georgi showed a slide of two cylinders, one of which was heavily sludged and the other practically clean. He said the change from the sludged to the clean cylinder was caused by a change in maintenance shop superintendents. The importance of regular oil changes, replacement of filter cartridges and periodic inspections should never be underestimated.

3. Engine Design. In engine design, emphasis should be given to proper use of by-pass thermostats in the cooling system, crankcase ventilators and oil filters of proper size. By using a by-pass thermostat the engine can be quickly brought up to the proper operating temperature, thus retarding the development of blow-by products which are harmful to the motor. A proper crankcase ventilator is necessary to remove the gases which are thrown off and which tend to place layers of varnish on the engine walls. The most efficient and expensive ventilator is one that is operated by a motor drive blower.

Oil filters in use today are generally too small for the job they must perform, and after a period of 8 to 12 operating hours the cartridges are so fouled that they are practically useless.

4. Poor burning fuels and improperly adjusted carburetors are responsible for crankcase dilution which quickly cuts down the efficiency of the oil.

In concluding, Georgi presented a comparison between a motor which was equipped with an undersize filter, poor crankcase ventilating system and no water by-pass, but was using a high-detergent oil, with a motor which had a dual filter, by-pass thermostat and a motor-driven blower crankcase ventilating system, but was using a premium oil without detergent. After operating under the same conditions and the same mileage the second motor was in far better shape than the first.

The meeting was under the direction of Technical Chairman Dr. J. C. Geniesse, of Atlantic Refining Co. Geniesse smoothly handled the unusually long and spirited discussion of the speaker's paper.

Detroit

April 16—This Section meeting reached out as far as possible into the future and dealt with jet-propelled race cars and the fruits of research—each subject being presented in a unique manner.

Jet propulsion was put before the membership in demonstration form when model jet racers sped down a wooden track erected along the wall of the Rackham banquet room where the dinner meeting was held. The occasion was the annual student dinner meeting and the racers were winners of individual school run-offs staged by the school SAE branches in the Detroit Section area. Entries from University of Detroit, University of Michigan, Michigan State College, Wayne University, Detroit Institute of Technology, Lawrence Institute of Technology and Chrysler Engineering School participated. The entry of General Motors Institute was "shipped" for the race but got lost in the mails.

The cars were powered by single carbon dioxide cartridges, and had to be 8 to 10 in. in length, at least 5 oz. in weight, not more than 2 in. high or $1\frac{1}{2}$ in. wide, with maximum hub-to-hub diameter of $1\frac{3}{4}$ in. During the 70-ft course set up behind the speakers table, one car lost a wheel, another's body split down the middle, and a third turned over—but all turned in official speeds of more than 43.30 mph.

The speed prize was won by the Chrysler entry with an average of 52.40 mph. A prize for excellence in workmanship and design was awarded to the Wayne University entry, with a special prize also awarded for design to the entry from Detroit Institute of Technology.

The technical talk of the evening was given by **C. G. A. Rosen**, research consultant to Caterpillar Tractor Company, who discussed "The Pay-Off in Research." Beginning his address he made the important point that our economic supremacy may soon rest on our creative ability in the United States, not on American wealth.

"The real reward of creative effort through continuous education is not the occasional prize, but the steady climb—the greater likelihood of advancement," Rosen said. His thesis was that

Sponsors Model-Car Design Contest

W. F. Sherman, Detroit Section Field Editor

attainment in research activities demands that we always have the attitude of the student: to seek knowledge by continuous study.

As to the value of college research Rosen gave testimony by listing engineering college research programs which have benefited the industry. These include dehumidifier testing, low cost housing, parking meters, transit system modernization, tractor testing, analyses of gases in steel, nepheline syenite, sugar beet mechanization, flax handling machinery, spectro-chemical analysis, and many others.

"The main reservoirs of fundamental research must be the college laboratories," Rosen said. "But this does not relieve industry of its share of responsibility of pursuing fundamental research vigorously."

He discussed the problem of financing research, directing it and keeping alive fundamentals and applied research without letting them get crowded by development projects.

"Under the guidance of management, with a properly balanced program in basic and applied research, with due regard to the sphere of evolution in product development, the profit statement of modern industry attests to the fact that research does pay off."

The speaker declared that a democracy creates a climate of opinion in which sound business can thrive. On the other hand, individuals can rise above governmental restraints and achieve developments of much credit to themselves, as has happened in a number of cases in European countries.

Rosen discussed the role of individuals in research and cited examples to bear out the truth of the quotation "all of us have within us some of the divine creative urge."

The real pay-off in research, he said, is "satisfaction in creativeness."

Chief Timer Chester Ricker, Detroit Editor of American Machinist (center) and students figuring time of cars. Times are being posted in the background

C. G. A. Rosen (right), speaker at the evening technical session, with Section Chairman L. I. Woolson (left) and Harry Chesebrough, vice-chairman for Student Activity

Frank S. Spring of Hudson Motor Car Co., chairman of the committee of judges, presenting a model car to Edward Solowiej of Wayne University, who built the car judged best in design

Chief Steward Tommy Milton presenting performance prize for the fastest car to Herb Smith and Bob Chapman of Chrysler Institute of Technology. They received an SAE banner (background) for the Student Branch and small model racing car pins. Left to right are H. E. Chesebrough, Section vice-chairman for Student Activity; Smith; Gordon Haag, Chrysler Institute; Milton; and Chapman

The California State Polytechnic College campus. Included are airplane hangars, poultry pens, chemistry labs, orange groves, and the multitude of other equipment needed for the variety of courses offered. A full-size airport, not shown in the picture, extends for 3300 acres into the mountains

SAE At California Polytechnic

One of the SAE's most unusual Student Branches is the two-year-old group at California State Polytechnic College, San Luis Obispo, for it's established at one of the nation's most unusual schools

Almost exactly midway between Los Angeles and San Francisco, at the point where U. S. Highways 1 and 101 converge, Cal Poly has become nation-famous as a learn-by-doing college with an "upside-down" approach to training. Results? Its all-men student body, pegged by the state at 2,700, includes representatives from 54 of California's 58 counties, from 42 of the 48 states, and from 19 foreign countries. And its engineering division, parent orbit of the SAE Branch, has more calls for graduates than it can supply.

While Cal Poly was first best-known for its agricultural division, the engineering program has grown by leaps and bounds until it is now on even terms. Growing so rapidly, the division has encouraged student clubs and society chapters as one of the best means of binding together the majors in its various departments. This is one reason the SAE Branch has had the staunch support of both students and faculty and why during the current year the Branch has grown in membership from some 50 to double that number. Membership is drawn primarily from five departments—aeronautic, mechanical, electrical, maintenance and agricultural engineering.

Meetings Stress New Ideas

Branch meetings are held every three weeks in Administration Building quarters. Programs stress study of new engineering techniques and practices, sparked frequently by appearance of leaders in the engineering field, who are available in passing to and from California's two largest cities. Among those attending Branch meetings recently were Don Van Harreveld, West Coast trainee engineer for Union Oil Co., who led discussion on trainee programs, and Jim Hodges, field engineer for duPont out of Los Angeles, who spoke on "Fuels and Lubricants."

Cal Poly's "upside-down approach" has been of particular interest to practicing engineers. Rather than require the student to spend two or more years with general education before starting specialization, Cal Poly believes that no engineering student should spend a single year without some definite engineering accomplishment to show for it. As a result, as many basic engineering and job-getting courses as possible are grouped during the freshman and sophomore years, and the third and fourth years are devoted to rounding out general education plus specialized advanced engineering work. Thus, a four-year student covers about the same material as students in other colleges but he has spent most of his engineering training building on early-learned fundamentals. In addition,

the student who may have to leave before graduation has the benefit of various courses basically important to an engineering or allied career.

Under the learn-by-doing system, students are given actual projects to design and carry through. In many cases, students borrow from a revolving fund to finance projects they expect to lead to cash profit. The aeronautic engineering student, for instance, may purchase a wrecked plane, repair it and sell it. The original loan, plus a percentage of the profits, is returned to the fund.

In other instances, engineering students are assigned "use-projects" for the college. In the machine shop not long ago, a dire need existed for a milling fixture to handle a number of metal blocks simultaneously. Production needed speeding up. William Martin, senior mechanical engineer, undertook to remedy the situation. The fixture he designed is hydraulically operated, clamping seven of the metal blocks into slots by two stellite-tipped points on each block. It permits a straddle milling operation.

Actually, the project was complicated by three basic requirements: (1) the fixture must clamp the blocks close together so that at any given time the cutters would not run idle between blocks; (2) no part of the fixture could project above the blocks, because such projection would interfere with the cutter arbor; (3) the fixture must be rigid enough to eliminate vibration.

The resulting fixture consisted of 209 parts, most ground to a precise fit. The seven pistons operating the clamping points have a tolerance of 0.0002 to 0.0005 in. The job required 600 man hours; would have cost $3,000 at prevailing wages.

"It simply proves again," says Dean of Engineering Ralph Priestley, "that gvien a chance, students can accomplish far more than some of the older heads are willing to realize. We try to make sure at Cal Poly that our engineering students use textbooks only as springboards. They study. They observe. But then they **do.**"

Mud was a vexing problem to the college, which has grown so rapidly sidewalks haven't been able to keep up. The maintenance engineers and the mechanical engineers got together. Now, before most of the campus classroom buildings are "grating platforms" where students almost automatically clean their shoes as they walk to the doors.

The architectural engineering department needed drafting tables. No money for quite some time and not enough then to provide for booming enrollment. Engineering students not only designed but built fifty drafting tables, so efficient that several improvements have been tagged for future use by professionals.

And that, points out Dean Priestley, is what is meant by Cal Poly's learn-by-doing.

Thomas Hardgrave, mechanical engineering instructor, is SAE student Branch adviser this year. Robert Faires, mechanical engineering senior from Santa Ana, is president. While the engineering division has been on display at a number of the West Coast trades and industrial conferences, and while April 27-28 saw Cal Poly as a giant open house for the nineteenth annual "Poly Royal," famous "Country Fair on a College Campus," both Hardgrove and Faires invite all engineers traveling over U. S. Highways 1 and 101 to stop in.

"We'd like to have them for one of our Branch meetings," says Faires, "and if they'll drop me a note at Box 264, Cal Poly, I'll be glad to tell them the next meeting date. But most of all, we'd like to show them this college that takes what we feel is an outstandingly 'real' approach to training. As students we not only learn what to do and how to do it, but then we actually go out and do it."

SAE Members Who Attended California State Polytechnic College

Clifford Howard Anderson (**1946-49**), John A. Benton (**1937-39**), Charles T. Coleman (**1946-48**), John L. Harnack (**1947-49**), Harold Bond Hunting, Jr., (**1935-38**), Harry Raymond Lewis (**1938-42**), Clinton Merithew (**1940-48**), Robert W. O'Hara (**1946-49**), Arsham D. Zakarian (**1937-40**).

Jim Hodges, duPont field engineer, talks with Student Branch officers after meeting at which he spoke on "Fuels and Lubricants." Hodges is only one of several in-the-field engineers to stop off at the College, where SAE Branch membership has doubled the past year. Left to right are Secretary Ed Whitney; Chairman Bob Faires; Hodges; Vice-Chairman Bill Martin; Treasurer Freeman Millard; Tom Hardgrove, faculty adviser and mechanical engineering instructor; and Hugh Heraldson, also a mechanical engineering instructor

Cal Poly's "Welding Goes to College" exhibit attracts attention at the recent Seventh Western Metal Congress in Oakland. Gathered around one of the drafting tables designed and constructed by Cal Poly engineering students on a "learn-by-doing" production basis are industry representatives discussing with Richard Wiley, welding department head, the Cal Poly exhibit theme of "production through education." Left to right: Charles E. Smith, Douglas Aircraft Co.; Wiley; Joe McGrath, national secretary, American Welding Society; Instructor Robinson, Laney Technical School, Oakland

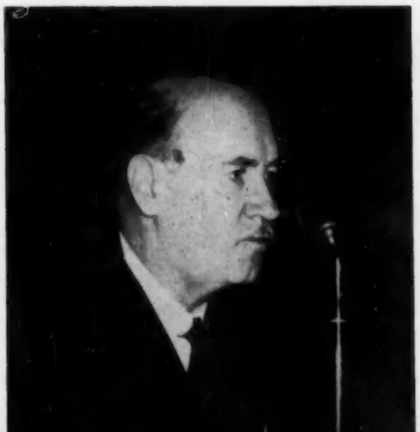
You'll be interested to know . . . .

TEN SAE MEMBERS are included in the 13-member Subcommittee on The Vehicle of the Committee on Engineering of the President's Highway Safety Conference this year. . . . SAE Past-President B. B. Bachman of Autocar is chairman of the Subcommittee. Other SAE members are: Donald Blanchard, secretary, SAE Technical Board; SAE Past-President J. M. Crawford, General Motors Corp.; Wilbur L. Cross, Motor Vehicle Department, State of Connecticut; Frederick L. Horner of Washington, D. C.; SAE Past-President W. S. James, Fram Corp.; George L. McCain, Chrysler Corp.; Val J. Roper, General Electric Co.; SAE Past-President S. W. Sparrow, Studebaker Corp.; and Harold T. Youngren, Ford Motor Co. . . . A meeting of the Committee will be held in Washington on June 12, the day before the Conference opens.

UNIVERSITY OF IDAHO now has an SAE Student Branch. The new Branch, approved by SAE Council on April 18, has been operating as an SAE Student Club for more than a year. Its smallest meeting so far had 10 in attendance; its largest, 170 . . . . Prof. C. D. King is faculty adviser; Joffre P. Myers is chairman for this school year . . . . U.I.'s Engineering College now has 339 students, and is a fully accredited school of engineering offering B.S. and M.E. degrees.

R. F. LANSING, BENDIX AVIATION CORP., has been named SAE representative on the Daniel Guggenheim Medal Board of Award for the three-year term beginning Oct. 1, 1951. He succeeds Alexander Kartveli, whose term expires Sept. 30, 1951. . . . Other SAE representatives now serving on this Board are Charles Froesch and W. G. Lundquist, whose terms will expire Sept. 30, 1952, and 1953, respectively.

RECENT ADDITIONS TO SAE Professional Activity Committees include: C. F. Kramer of Ford to the Body Activity Committee; C. G. A. Rosen of Caterpillar and T. M. Robie of Fairbanks, Morse to the Diesel Engine Activity Committee; T. A. Haller of Allis-Chalmers, W. W. Henning of International Harvester, D. K. Heiple of LeTourneau, and G. J. Storatz of Heil to the Tractor and Farm Machinery Activity; and F. W. Kately, ACF-Brill Motors, to the Truck & Bus Activity Committee.



Guest speaker Igor Sikorsky at Montreal Section's April 17 meeting

Helicopter Role Seen Growing Fast

• Montreal Section

Frank B. Thompson, Field Editor

April 17—**Igor Sikorsky** sees development ahead of great helicopter "air buses" to carry passengers from airports to central parts of a city and for relatively short intercity flights. Sikorsky, designer of the Sikorsky Helicopter built by United Aircraft Corp., pointed out that airplanes are limited in service possibilities by their need for airports for take-off and landing. The helicopter, however, can land almost anywhere because it can go straight up and down.

Use of the newly-developed 10-passenger helicopter in Korea, he said, has demonstrated possibilities limited only by the imagination of the helicopter designer of the future.

The meeting, held jointly by the SAE Montreal Section and the Institute of Aeronautical Sciences, took place at the Mount Royal Hotel.

Says Human Factors Cause Most Accidents

• Metropolitan Section

C. F. Foell, Field Editor

April 5—Met Section was entertained tonight by a very illuminating discussion on the human factors in automotive design and operation by **Dr. Ross A. McFarland** of Harvard University's School of Public Health. At the outset, the speaker stressed the breadth and intensity of the subject, pointing out the indispensable nature of automotive transportation as well as its far-from-enviable accident rate. In his opinion, effective reduction of the latter can result from the combined efforts of designers, physicians, physiologists, and psychologists, primarily; improved public health should also be realizable. The goals are worthwhile when one considers the approximate annual highway toll: 35,000 deaths, 100,000 major injuries, 1,000,000 minor injuries. Accidents from all sources are the major causes of death between the ages of one and 24 years.

McFarland is of the opinion that while design defects are important contributary causes, and are often considered the most important, human failures are of first importance. In support of his theory, he cited an analysis of 300 cases from a single insurance company's experience, involving several million dollars in claims. The causes of the accidents were about as follows, in descending frequency: Unfamiliarity with the road, driving too fast, driving too close to the vehicle ahead, driver fatigue, faulty passing, excessive drinking, design defects.

According to the speaker, human differences cause machines to respond differently; there has not been sufficient matching of people to apparatus and, in addition, there has often been too much designing for the average man without accurate knowledge of the characteristics of that composite individual. The non-average man needs plenty of consideration, too.

Important vehicle properties requiring improved design were cited: vision point and angle, susceptibility to reflection and glare, seat height and adjustment, pedal position and travel (too close or too far from driver, or from each other; at wrong angle to driver's feet), hand operated controls (not readily accessible or convenient of use), leg clearance, instrument visibility and lighting. Reduction of noise and vibration, which cause fatigue, as

Continued on Page 97

25 Years Ago

Facts and Opinions from SAE Journal of June, 1926

Noted as "radical aerodynamic departures from the conventional airplane" by Prof. Alexander Klemin of New York University are the slotted wing and flap for the increase of the maximum lift of an airfoil; the slotted wing and flap utilized as ailerons to improve lateral control at low speeds; La Cierva's Autogyro; and Capt. G. T. R. Hill's tailless airplane. Prof. Klemin spoke at the May 20 Metropolitan Section meeting.

■

Undoubtedly the most spectacular feature of the 1926 Summer Meeting was the airplane photographic exhibition provided in connection with the Army's experimental program through the courtesy of Maj. J. F. Curry, commanding officer, McCook Field. This first public demonstration of the Army's new quick photography apparatus was made when the Army plane flew over the crowd of members assembled to form the initials S A E.

■

Preliminary deductions from cooperative road impact tests conducted by the Bureau of Public Roads, the Rubber Association, and the SAE were reported in a Summer Meeting paper by James A. Buchanon of the Bureau and J. W. Reid of the Rubber Association. The preliminary deductions included:

(1) Thickness and narrowness of tread rubber are desirable in reducing road-impact reaction; (2) Increasing thickness of profile height of rubber has a very marked effect in reducing road-impact reaction in both single and dual mountings; (3) Dual-mounted tires should always be mounted with tread designs staggered; (4) Appreciable variation in cross-sectional rubber, or breaks in its continuity, cause heavy repeated impacts on the road.

■

Suggestions for avoiding carbon trouble from S. P. Marley, C. J. Livingstone, and W. S. Gruse of Mellon Institute of Industrial Research: (a) keep oil consumption at a minimum; (b) avoid excessive and irregular cooling; (c) keep fuel-air mixture on the lean side of smooth operation; (d) use the oil that is the most volatile among those of the same viscosity. (In paper on "Influence of Temperature, Fuel, and Oil on Carbon Deposition.")

■

Described at the Summer Meeting by K. D. Chambers of Asheville, N. C. was a complementary-color headlighting system. In it, each lamp is oval and contains two paraboloid reflectors, one emitting light through an orange glass filter, the other through one of blue glass. While driving at night, the driver looks through a viewing-filter of transparent glass of the same color as that of the headlight which is in use.

■

"Street cars used to be purchased for a life of 20 years, and it was not unusual to run them for 10 years or longer," says Alexander Shapiro of Washington Rapid Transit Co. in his paper "Problems of Intercity Motorcoach Operation." Some motor coach builders, he noted, have tended to produce vehicles on the same plan.

"If the public wants a vehicle that resembles a passenger car," he went on, "should we not encourage the building of motor coaches that will have a life of only four or five years at most—and give every opportunity for continued improvement of models rather than to have a large investment tied up in high-priced equipment which would prevent buying more up-to-date equipment?"

■

Measurements of axle accelerations and displacements indicate the need of concentration at this time on the correlation of the various factors entering into riding qualities. However, a finite evaluation cannot be reached without investigation of physical and mental effects. The need for such an investigation is apparent.—Roy W. Brown in "Instrumentation and Results of Riding-Qualities Tests."

Continued from Page 94

well as possibility of exhaust gas leakage into vehicle, are considered very important.

The speaker concluded with some observations of the human element involved. Young drivers have better night vision than older drivers, and night vision decreases quite rapidly as one gets older. On the other hand, there is no important difference in reaction times by age levels. Older persons are emotionally more steady and less excitable. All age classes are affected by excessive smoking, drinking and eating, all of which contribute to greater fatigue.

McFarland drew on his extensive aviation experience in pointing up many parts of his discussion. He has been medical coordinator of Pan American World Airways System since 1937. He is also a member of the operating committee of the National Advisory Committee for Aeronautics and the President's Conference on Industrial Safety.

This meeting was arranged for and presided over by D. F. Geisey, Passenger Car & Body Activity vice-chairman.

Tells CAA Role In Air Safety

• Mohawk-Hudson Group

D. C. Peroutky, Field Editor

The role played by the Civil Aeronautics Administration in aviation safety was interestingly portrayed by one of its agents, **E. N. Morey**, at a Section meeting at the Albany Airport.

The speaker pointed out that few who make use of air transportation realize the behind-the-scenes activities that are constantly in progress to assure the high degree of safety in air travel that is possible today. The responsibility for maintaining that safety is vested in the Civil Aeronautics Administration. Its job is to test and certify the competency of pilots and other specialized aviation personnel; inspect and determine the airworthiness of flying aircraft; staff and maintain air traffic control centers; and, in many cases, aid in the building and improving of landing fields. The CAA works closely with the Civil Aeronautics Board, which has the job of promulgating the Civil Air Regulations and considering the applications of airlines for routes and rates. The CAA, in cooperation with the CAB, also investigates major air accidents and prosecutes violations of the Civil Air Regulations.

In addition to these tangible but often overlooked activities, the CAA

is taking active interest in aviation education. CAA professional help is given to a number of teacher colleges in the conducting of special aviation courses to foster the establishment of air-mindedness in the coming generation. The CAA also maintains a Technical Development Center at Indianapolis to further scientific advances in aviation through fundamental research, applied development, and production engineering.

Morey illustrated his talk with a movie which emphasized government responsibility in aviation safety. Following the movie, and assisted by other members of the local CAA staff, the group was taken on an inspection tour of the CAA facilities at the Albany Airport. The air traffic control tower was visited for first-hand inspection of the facilities and methods used to control local air traffic around the Albany Airport. The role played by the air traffic control center in regulating traffic on the Federal airways in the Albany region was demonstrated. The means for obtaining weather information to aid in the safety of air travel was emphasized by inspection of the Airport's weather station.

Describes Features of New Chrysler Engine

• Pittsburgh Section
H. K. Siefers, Field Editor

April 24—"Performance, efficiency, durability and general operating characteristics of new Chrysler Vee type, 8-cyl engine are outstanding" said guest speaker **W. E. Drinkard**, department head, Chrysler Laboratories, at this meeting of the Pittsburgh Section.

Following closely the paper "Development Highlights & Unique Features of the New Chrysler V-8 Engine" which he co-edited with M. L. Carpentier and presented at the SAE National Passenger Car, Body and Materials Meeting in Detroit, Drinkard discussed in detail the various features of this new valve-in-head powerplant.

Most interesting of these were the hemispherical combustion chamber design, cam and valve mechanism design, high volumetric and thermal efficiency, low heat rejection to the coolant, maintenance of high performance when combustion chamber deposits have accumulated, and the high compression ratio (7.5-1) without requiring the use of premium grade gasoline.

During the open discussion period, decided interest was shown in the water-heated throttle valve, Drinkard claimed that it had definitely eliminated carburetor icing.

In response to a query about bearing material and design, it was revealed that the same bearing materials as previously were used, but increased fatigue resistance was gained by re-

ducing the top limit of the babbitt thickness tolerance.

The inevitable miles-per-gallon question brought the statement from the speaker that the new V-8 engine would deliver about 1 to 1½ more mpg than their equivalent in line L-head eight cylinder motor.

More rapid oil warm-up is achieved through the smaller crank case and larger piston area, thus minimizing engine wear during cold weather starts. No change was made by Chrysler in their recommendation of type of crank-case oil for the new engine.

Although the engine was designed to operate on regular grade gasoline, an increase of approximately 5 bmep was said to be obtainable at the low speed range by the use of premium fuels.

Murray Fahnestock, editor of Ford Field Magazine, proved that coming events really do cast their shadows ahead when he reminded the audience that Alex Taub, a former Chevrolet engineer, had appeared before the Pittsburgh Section several years ago discussing "Mechanical Octanes." At that time, Taub claimed that too little emphasis had been placed on reducing the octane requirement for a given compression ratio, by more expert design of the combustion chamber. He said that the petroleum people had done a wonderful job in producing chemical octanes with, of course, a lower yield and increased cost; but that the automotive engineers had overlooked the possibilities in "Mechanical Octanes" by advanced combustion chamber design. Chrysler has, of course, done just this, so it appears that those attending SAE meetings regularly might well get the news of automotive developments before they happen.

The large attendance and active discussion period attested to the keen interest in new passenger car powerplant developments.

Tells Fleet Experience With Diesel-Powered Buses

• Metropolitan Section

C. F. Foell, Field Editor

May 3—In 1946, diesel-powered buses comprised 6%, and in 1950, 46%, of the fleet of The Connecticut Co., according to **Robert H. Fraser**, who discussed diesels in transit systems at this meeting. This large increase in only four

years resulted from the diesel's proved fuel economy and ability to match maintenance costs with gasoline-engined vehicles.

This company's diesel experience began in 1939 with two units so powered. Operating costs of those early vehicles was 3.533¢ per mile, against 4.312¢ per mile for gasoline units. As newer units were added in the next few years, comparable costs were 2.50¢ per mile for diesel and 3.14¢ for gasoline-powered jobs.

According to Fraser, fuel cost per mile is the predominant deciding factor when selecting the type of power to be used. Fuel savings in approximately the first year of operation should just about wipe out the diesel engine's higher first cost.

Data on maintenance proved interesting. Per-mile cost of maintenance, excluding tires and inspection, averaged 3.04¢ for diesel and 2.98¢ for gasoline, for all practical purposes a stand-off. Actual miles per mechanical failure were approximately 50% more in the case of the diesel units.

The speaker added comments of a general nature valuable to all diesel bus fleet operators. Detergent oils are necessary, and use of premium fuels may often perform a good job of public relations through reduction in smoke and odor. The latter is especially desirable when operations are largely urban in character. Drivers generally prefer diesels, but some believe them too noisy. Precautions to avoid excessive idling are necessary, since engines with piston cooling are subject to overheating under idle conditions.

This meeting was arranged jointly by L. F. Moody, Jr. and Neil P. Flynn, vice-chairman respectively for Diesel Activity and for Fuels and Lubricants Activity. Richard S. Woodbury, assistant vice-chairman for Diesel, presided.

"Automation" is Topic of Ford Engineer's Talk

• Buffalo Section
D. C. Appleby, Field Editor

April 24—"Automation" was defined as extensive use of mechanical means of moving work from one machine to another or from one station to another on a given machine by Ford's **H. A. Franke.** Election of 1951-1952 Section officers was announced at this same meeting at which Franke spoke.

Many methods of moving work mechanically are used at Ford, this Staff Automation Engineer said. It has been applied, for instance, to simplifying blank feeding of the presses, removal of formed parts, and to transmission of these parts through forming, trimming and welding operations. Franke showed slides to depict visually what has been accomplished. Direct saving in manpower-hours was a main result described by Franke.

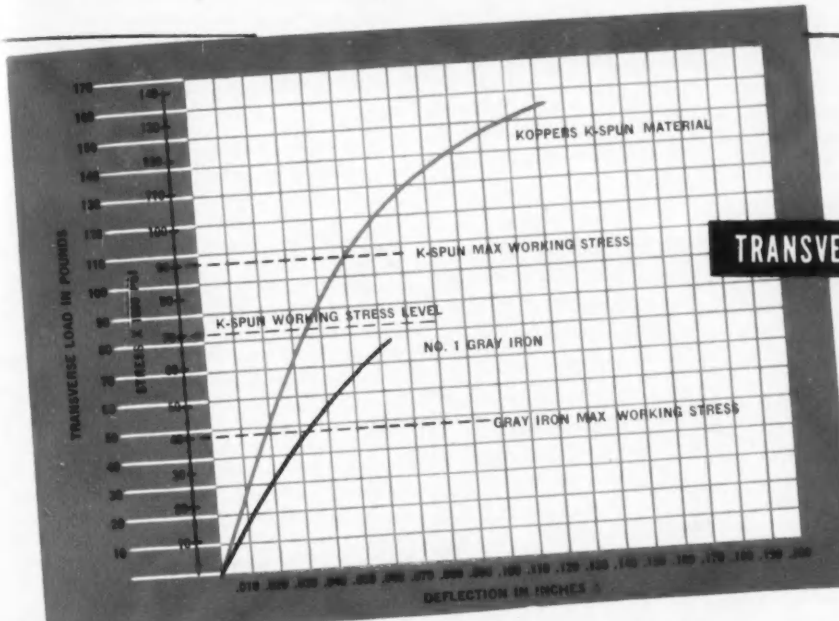
Section officers for 1951-1952 Section year were announced as follows: R. W. Morgan, chairman; C. J. Lane, vice-chairman; B. Frente, Secretary and Treasurer.

Tells Military Uses Of Light Aircraft

• Western Michigan Section
L. W. Kibbey, Field Editor

April 17—Most of the members present at this meeting were surprised at the numerous uses to which light aircraft are put by the U. S. Army. They serve as spotters to detect enemy movements,

Here's PROOF that Koppers K-Spun Piston Rings are TWICE AS STRONG!



HERE ARE THE AMAZING RESULTS OF ACTUAL LABORATORY TESTS COMPARING ORDINARY GRAY IRON WITH KOPPERS K-SPUN, *THE MIRACLE METAL!*

TRANSVERSE STRESS CHART

Koppers K-Spun material shows a maximum working stress of 90,000 psi, compared with a maximum working stress of *only 40,000 psi for ordinary gray iron piston ring material!* Note the difference in the slopes of the two curves, due to K-Spun's increased modulus. K-Spun's yield point, though approaching ultimate strength, is low enough to allow a small percentage of elongation, resulting in toughness and impact value *many times greater* than that of ordinary gray iron.

TABLE 1—TRANSVERSE MODULUS AND RUPTURE STRESS

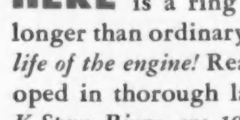
Koppers K-Spun Material			No. 1 Gray Iron		
TRANSVERSE MODULUS at			TRANSVERSE MODULUS at		
40,000 # psi	60,000 # psi	90,000 # psi	40,000 # psi	60,000 # psi	90,000 # psi
22.0×10^6	20.6×10^6	18.6×10^6	12.4×10^6	10.8×10^6	... .
RUPTURE STRESS psi			RUPTURE STRESS psi		
130,000			67,000		

TABLE 2—HARDNESS, IMPACT AND TENSILE STRENGTH

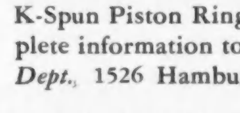
Koppers K-Spun Material			No. 1 Gray Iron		
Hardness R_b	Impact in lbs.	Tensile Stren., psi	Hardness R_b	Impact in lbs.	Tensile Stren., psi
100-103	9.5- 9.5	75,400	102-104	2.5-3.0	42,000
99-100	11.0-11.5	72,900	103-104	2.5-3.0	40,000
105-106	7.0- 5.0	76,000	101-103	3.0-3.0	41,000
99-102	7.0- 8.0	79,100	103-105	2.5-3.0	42,000
98-100	8.5-10.0	76,500	104-105	3.0-3.0	42,300
103-104	6.0- 7.0	77,500	102-103	3.5-3.5	38,000
101-102	7.0- 8.5	78,000	104-105	2.5-2.5	40,000

HERE is a ring that provides better oil control, lasts far longer than ordinary rings, is *guaranteed against breakage for the life of the engine!* Read for yourself these facts and figures, developed in thorough laboratory tests . . . *clear demonstration that K-Spun Rings are 100% stronger and four times more resistant to combustion shock than ordinary rings!* Get the facts on Koppers K-Spun Piston Rings for *your* engine today . . . write for complete information to: KOPPERS COMPANY, INC., *Piston Ring Dept.,* 1526 Hamburg St., Baltimore 3, Maryland.

K-SPUN IS AN ENTIRELY DIFFERENT KIND OF RING MATERIAL



ORDINARY CAST IRON



KOPPERS K-SPUN

These microstructures, magnified 250 times, show the basic difference between ordinary cast iron and Koppers K-Spun. Top photo shows individually cast gray iron, containing spiral flake graphite with long stringers in a fine pearlitic matrix. This fine flake graphite imparts to the metal many planes of weakness, causing low resistance to combustion shock.

Bottom photo shows K-Spun, cast by an exclusive centrifugal process. Note large nodular type of graphite formation and absence of stringers. Large graphite nodules eliminate the many planes of weakness inherent in most cast iron . . . double impact resistance and elasticity . . . increases wear resistance by far . . . in amazing Koppers K-Spun Piston Rings!

POROUS CHROME PISTON RINGS
. . . another Koppers Exclusive!

Koppers Porous Chrome Rings reduce cylinder wall wear 50% or more by actual test! Famous Van der Horst Plating Process provides a porous chrome surface that distributes oil for better lubrication during break-in, wears down to perfectly seated solid chrome that gives up to four *times as much service* between overhauls! For gasoline and Diesel engines (on specification).

KOPPERS

KOPPERS *American Hammered* PISTON RINGS

and are an important factor with the artillery units as target finders and in the direction of artillery fire. They carry excellent two-way radio equipment and are in contact with the ground force, artillery, headquarters and air corps planes during engagements. They assist high-level bombing through their ability to find objectives and radio positions. They have often assisted the signal corps by laying telephone wire over rough terrain which ground crews could not cover.

This information was revealed by **Major Michael J. Strouck** of Army Ordnance, who also had much to say regarding the responsibility of the Ordnance Department to all branches of the service and the maintenance setup as related to aircraft and other vehicles. He has been instrumental in promoting the specialized uses for light planes in the Army and more recently has given a large part of his time to the investigation of rotating wing and convertiplane types. He said experience with the rotating wing type in the present Korean campaign has proved its value. Much material was moved up to the front lines which would not have arrived in time if it depended entirely on ground transportation. Helicopter evacuation from the battle front has saved many lives of wounded.

Strouck said the diversified all-round uses of both fixed and rotating wing type vehicles place them in an indispensable category, and that the commanding officers now would have difficulty in conducting a campaign of any kind without their assistance.

After his talk, Strouck served as narrator for a colored movie provided by Hiller Co., showing their ramjet helicopter—a two-place vehicle with a huge plexiglass bowl that gives unlimited vision. The ramjet engine weighs 11 lb and develops 30 lb thrust. It is mounted 12 ft from center of rotor, an arrangement which produces a gyroscopic effect that gives the craft more stability than the conventional engine-driven type.

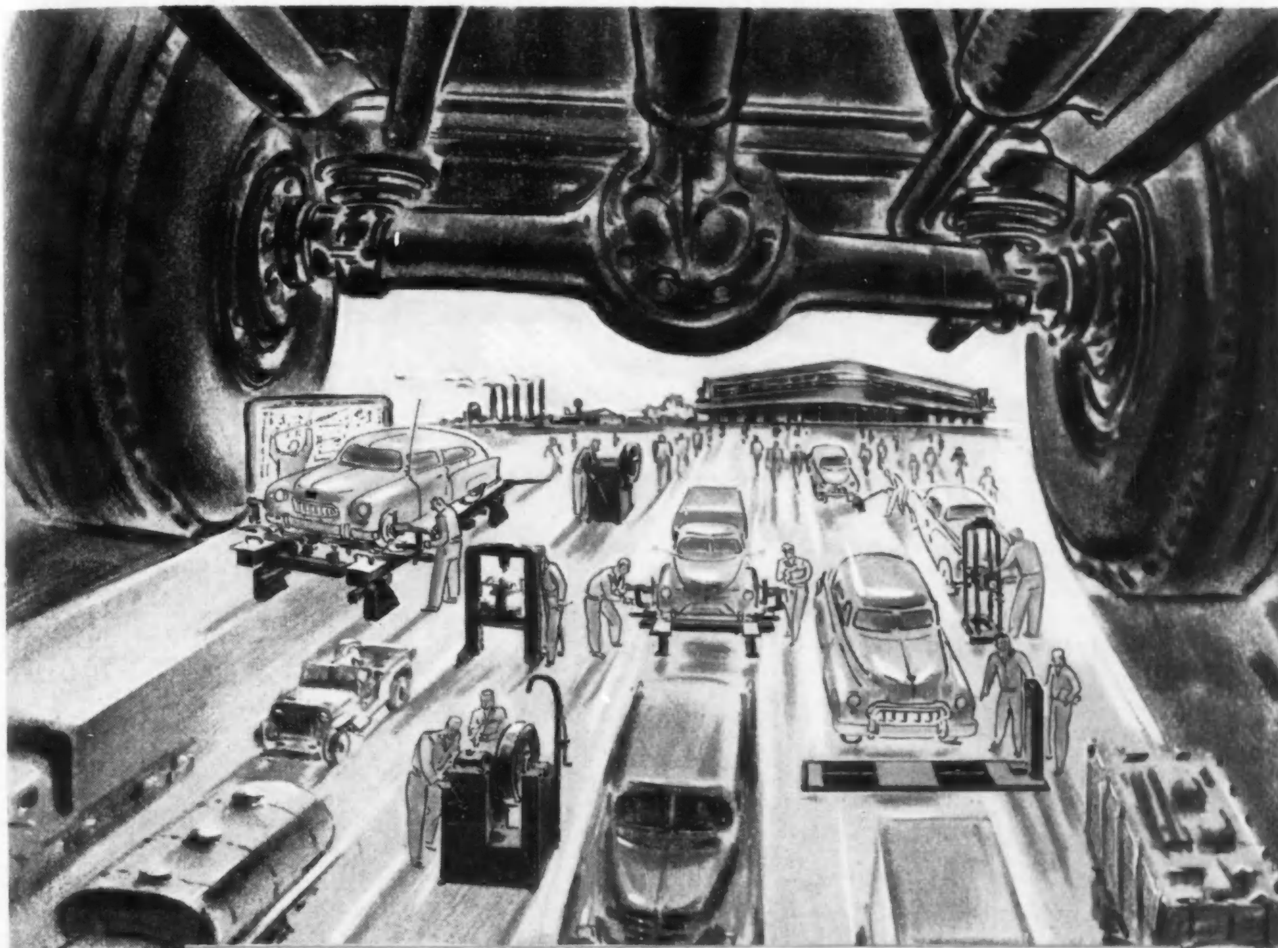
Tells Current Status Of Synthetic Rubber

• Washington Section
Louis Reznek, Field Editor

April 14—Members present at this meeting received an insight into the Government's rubber program and recent developments in synthetic rubber production from **Carl W. Gay**, assistant manager of the research and development division of the Office of Rubber Reserve. Gay spoke on "Synthetic Rubber for Transport Purposes."

The paper indicated that the present demand for GRS exceeds the supply and this is one of the main reasons for distribution being controlled by the Government. The production of GRS in April 1950 was 25,000 long tons per month; in April 1951 it was 50,000; and in July 1951 it is scheduled to reach 63,000. Present plans call for about 860,000 long tons of GRS in 1952.

The speaker also discussed tests being conducted by the Army at Fort Bullis, Texas, to determine the characteristics and suitability of various types of synthetic rubber for various designs of army vehicles. The tests cover wheeled vehicles principally, but tests on track-laying vehicles are also being conducted. The tests cover both off-highway and highway work and the tests already conducted seem to indicate that some synthetics are suitable for tires of all sizes for military purposes. This may not, however, be applicable to commercial vehicles because of their



higher speeds and heavier loads.

The Office of Rubber Reserve is indicated as being particularly interested in four phases of rubber development: (a) The use of low styrene polymers for tires; (b) the development of polymers for large tires; (c) the use of cold rubber in tubes; and (d) the extension of the supply of GRS by master-batching with oil by adding 25% oil to the liquid synthetic latex.

Gay said tests have indicated that synthetics with much lower styrene content can be used without sacrifice in quality but that this results in more difficult processing. The charts and tables presented with the paper developed the subject in quantitative terms and pointed up the fact that there are new processes and synthetics being developed which, in conjunction with processes already in use, will alleviate the shortage. At the same time increased production and substitution of more readily available types will bring production in line with needs.

TWA President Speaks On Air Transport Progress

• Baltimore Section
G. H. Rice, Jr., Field Editor

April 12—Over 150 SAE members and guests, including representatives of most of the major airlines and of other local companies, were present at this meeting to hear Trans World Airline's president **Ralph S. Damon** tell of his recent experiences as a world air traveler.

He told of the great contributions of the airplane not only in cutting down distance, but in bringing about closer understanding among different peoples.

Damon said the airlines are carrying more people abroad than ever before, and doing it more efficiently. They have finally reached a long-sought goal of public acceptance of the availability, reliability, and safety of air travel. He is sure that 1951 is going to be the greatest year yet for overseas air travel.

Chairman Raymond T. Long presided, and Vice-Chairman for Aviation Albert S. Polk arranged the meeting and introduced Damon. Also at the speakers' table were Earle Constable, TWA treasurer; Robert L. Rummel, TWA chief engineer; Donald Benson, chief engineer of Northwest Airlines; C. C. Pearson, president of Glenn L. Martin Co.; Gen. Donald Connally, director of Baltimore City Airports; Capt. C. H. Schildhauer, aviation director of the Baltimore Chamber of Commerce; and George Coleman, Section vice-chairman.

Stresses Importance Of Gear Lubricants

• Southern California Section
R. E. Strasser, Field Editor

March 15—The development of automotive gear lubricants is closely associated with the trend toward higher loads and speeds in modern automotive equipment, said **John M. Stokely**, senior research engineer, California Research Corp.

Stokely said that the contrast between lubrication of an automotive engine and the rest of the vehicle is quite striking. The motor oil is normally changed many times for each gear oil change or bearing packing. The engine is provided with forced feed lubrication, while complex gear cases are provided with crude dip or splash methods of lubrication. Another example is the few ounces of grease provided in wheel bearings which are expected to perform satisfactorily for long periods of time under extreme variations of temperature and at heavy

loads and high rotational speeds. It is evident, therefore, that the lubricants provided for gear and chassis parts must be able to survive in the most severe conditions.

The most common gear lubrication problems are oxidation or sludging, wear characteristics, rusting and corrosion, contamination, and wash-out. Most of the chassis lubrication points on automotive equipment do not rotate, but oscillate over a small arc. This motion forces the lubricant out of loaded contact surface resulting in wear, and increases the problems for the lubricant.

The all-purpose automotive greases are relatively new in the field of lubricants and as the name implies are designed to be used for all automotive applications. Some of the problems of such a lubricant are: control of texture, prevention of rust damage, provision of adequate anti-wear and load-carrying capacity, and provision of exceptional pumpability.

Stokely concluded by saying that a new truck may weigh thousands of pounds, but it is worn out when only a few ounces of metal are worn from vital moving parts. These parts are protected only by the lubricant film, and the vehicle operator has it within his power to determine whether this wear will occur in a few months or over a period of years.

SAE Student News

Naval Academy Club Completes First Year

• U. S. Naval Academy
W. D. Sayer, Secretary

Activities of the SAE Club at Annapolis have centered during its first year around its internal combustion engines laboratory, where two groups have been working in research and mechanics. The research group began a project on fuel additives and combustion ratios affecting antiknock qualities, using CFR engines. The mechanics group, under supervision of a master mechanic, worked on a Cadillac V8 engine, a Budd diesel, a Wright aircraft engine, and a fluid transmission.

With the closing of the lab for re-

modelling early in the spring, movies, field trips and speakers took the place of these enterprises. The movies were on the 1950 Grand Canyon Economy Run and the Indianapolis Memorial Day Race; the speakers (both of the faculty): Lieutenant Hafer on gas turbines in industry, and Prof. E. J. Ziurys on development of an engineering project.

The Club now has 32 Enrolled Students.

University of Detroit Branch Has Busy Year

Four meetings and two plant tours comprise the successful activities of the SAE Student Branch at University of Detroit up until the middle of April, 1951. Chairman James R. Phelan left the University last November, and Thomas Bischoff assumed the duties of chairman for the latter part of the school year.

The plant tours were to Packard last Sept. 29 and to the General Motors Truck & Coach plant at Pontiac on Nov. 1. Sixty-five members toured the Packard operation, while only 15 made the longer trip to Pontiac.

Regular meetings included an opening session on Sept. 15 which was devoted to business matters of the Branch. Speakers at other meetings were: Student Branch member Robert Les on Chrysler's disc brakes; Howard Preston, Sporting Car Club of America, on American and European sport car design and abilities; and Everett Moeller of Chrysler on Chrysler's new V-8 engine.

Oil Qualities and Aims Are Analyzed

• University of Colorado

S. W. Clayman, Field Editor

April 11—"Even the average engineer doesn't know too much about lubricating oils," **E. R. Grassmuck** of Sinclair Oil Co. told a meeting of the University of Colorado professional engineering societies. Participation in this meeting constituted this month's SAE Student Branch meeting.

Grassmuck's talk preceded a demonstration of the different properties of mineral and premium oils. He came from his Kansas City headquarters to speak to the university students.

"No oil is any better than the refinery which makes it," according to

Grassmuck, who said that no additive can improve the quality of the base oil. Continuing he said in effect:

The only mandatory requirement for a premium oil is that it contain an oxidation and corrosion inhibitor. Other additives are added at the manufacturer's election.

Additives are needed to counteract the bad effects of the compounds formed by modern gasolines. Acids, peroxides, tars, and gums are formed from the products of combustion, and these elements attack the parts of the engine while the insolubles settle out as varnishes and lacquers. Any good lubricating oil will oxidize, with the rate of oxidation doubling for every 18 F rise in temperature of the lubricating oil. The inhibitors placed in the oil are not expected to stop this action, but instead are expected to retard oxidation and reduction.

A lubricating oil must lubricate, cool, seal, and clean the engine. The amount of oil used is an indication of the amount of wear or tightness of the parts in an engine. No lubricating oil can stop this natural wear but if the engine is getting proper lubrication the oil will retard or slow down the wear.

Rate of heat transfer in an engine is determined by thickness of the oil film. More heat is transferred to the cooling medium through a thin film of oil. The viscosity index is therefore an important feature in any lubricating oil. If the viscosity index is low the oil will break down faster and will not properly lubricate nor transfer the heat produced in the engine.

Straight mineral oils are good lubricants, but do not retard the bad effects from the products of combustion. Straight mineral oils do not disburse the products of oxidation, but instead, allow these products to form a coat of sludge on the cylinder walls, rings, and other parts with which they come in contact. This condition is what may help to cause a sluggish engine and it also reduces the life of an engine.

Premium oils, or those oils with the required additives in them, will disburse products of oxidation and help to keep the engine clean. Premium oils are meant to keep a clean engine clean. They may be used in old engines that previously have been run with straight mineral oils, provided that it is known that these engines are still tight and have sufficient ring tension, since a premium oil will tend to remove all of the carbon and sludge that has been formed in the engine, prior to the use of premium oils.

A demonstration was then given to show the various and different properties of mineral oils and premium oils. The discussion was then opened to questions from the audience.

Field Trips Feature Northrop Student Year

• Northrop Aeronautical Institute
J. A. Brown, Field Editor

Trips to nearby Columbia Steel Corp. and Firestone Tire & Rubber Co. were important features of the year up to April 1st for the SAE Student Branch at Northrop.

At Columbia, on Jan. 31, the Branch members toured the plant in four separate groups. Each group had a Columbia metallurgical engineer as a guide and were able to get all their questions answered about making and forming of steel.

The trip to the Firestone South Gate plant on March 12 drew 92 Branch members, who saw tires made from raw

material to finished state. Members stood close to operators and machines wherever they wished and were able to observe the smallest details of operation.

At the Branch's April 4 meeting, nominations were made for next year's Branch officers.

Students Hear Piston Ring Expert

• University of Washington

K. W. Macdonald, Secretary

April 3—Students present at this noon meeting learned of the developments which have brought piston rings to their present high standards, and got some tips on proper application of various types of rings and the service to which they may be put. Speaker was **W. H. Hendrickson** of American Hammered Piston Ring Co.

Hendrickson pointed out some of the great problems that confront ring manufacturers at the present time. For instance, rings are being made thinner and thinner and are still expected to have long and effective life, conform to cylinder walls, and act as heat transfer media all in one. He demonstrated the toughness of "K spun" rings by actually bending them through an angle of 180 deg before they broke.

Students agreed this was one of their finest meetings.

Aeronautical U. Goes to Studebaker

• Aeronautical University

Fred Clemens, Field Editor

April 17 — Fifty-five SAE Student Branch members, accompanied by Faculty Adviser L. W. Sims, visited the Studebaker plants at South Bend today. They were given a guided tour by Studebaker's Charles V. Niptie, Edgar W. Pigg, and James W. McAllister.

The tour followed through the complete assembly operation as well as some of the manufacturing processes.

In the stamping room, students saw large mechanized giants making front and rear fenders, hoods, oil pans, gasoline tanks, engine support plates, and numerous other stampings. All the stampings, except the large sheet-metal body stampings are made in the South Bend plant.

The body stampings move on over-

head conveyors to the assembly department where hundreds of special jigs and fixtures locate and hold them in exactly the right position while they are being welded together.

Many facilities for assuring speed and uniformity are provided. The students watched the skilled workers as they performed the final welding operations. Varying grades of sanding belts are used as the body progresses down the metal finishing lines.

In the painting department, a prime coating, inside and out, is put on, then baked in an oven at 250 F for an hour and a quarter. Then two more coats of primer-surfacer, then back into the baking ovens. After sanding and wasning, the body is sprayed with two heavy coats of color enamel and oven dried at 260 F.

The students passed through the upholstery department, the final assembly room, the Studebaker foundry, where all of the castings are made, and the machine shop, which is approximately nine acres of floor space.

Detroit Institute of Technology

Morgan B. Lawton, manager of the Detroit sales branch of Lincoln Engineering Co., was guest speaker at the May 2 meeting of the D.I.T. Student Branch. He explained, with the use of slides, the operation of service lubrication systems for automobiles.

At a recent coffee hour, the Branch heard C. E. Broders, engineering superintendent of the Govro-Nelson Co., give an informative talk on jet turbine parts, their operation and manufacture. He exhibited samples of some of the parts his company processes.

General Motors Institute

The GMI Student Branch held its annual dinner meeting in April, with K. A. Stonex, head of the technical data department at General Motors Proving Ground as guest speaker. Stonex gave an interesting account of activities at the Proving Ground and showed a film depicting various types of tests and the general layout of the Ground.

Manhattan College

SAE Students cooperated with AIEE and IRE students in a recent engineering smoker. The highly successful affair drew an attendance of 260 and raised $150, donated to the Manhattan Scholarship Fund to help students who have passed their sophomore year and cannot continue further. Students provided the entertainment, and World Series movies were also shown. Plans are to make this an annual event.

—Albert C. Dolbec, Secretary

Continued from Page 78

pressure and 60 F). In the new version, the formula is:

$$\text{Corrected bhp} = \left((\text{Observed bhp} + \text{fhp}) \times \frac{29.92}{(\mathbf{B} - \mathbf{E})} \times \sqrt{\frac{460 + \mathbf{t}}{520}} \right) - \text{fhp}$$

Formerly, the correction factor was applied only to observed brake horsepower.

The new Rules and Directions sheet is prefaced with a note that "The purpose of this code is to provide a means of comparing gasoline engines. It is not intended as a laboratory manual. An infallible and simplified method of correcting power output is not believed possible at this date. This code is considered the nearest present-day practical approach."

Copies of the new Rules and Directions sheet are now available through the SAE Special Publications Divisio[n]. Price is 10¢ to members and 20¢ t[o] nonmembers for single copies, 8¢ eac[h] for orders of 10 to 99 copies, and 7[¢] each for orders of more than 10[0] copies.

The other SAE Gasoline Engine Tes[t] Code forms (Forms GB-1 and GB-2, GC, and GD-1 to GD-6) have not bee[n] changed.

Technical Board Approves 67 AMS

SIXTY-SEVEN Aeronautical Material Specifications were approved recently by the SAE Technical Board. They are:

- AMS 2212B, Tolerances, Magnesium Alloy Sheet and Plate
- AMS 2407A, Chromium Plating, Porus
- AMS 3002A, Alcohol, Denatured Ethyl
- AMS 3004A, Alcohol, Methyl
- AMS 3006A, Alcohol, Water Mixtures
- AMS 3087B, Compound, Insulation and Sealing
- AMS 3270A, Synthetic Rubber Sheet, Cotton Fabric Reinforced, Weather Resistant—Chloroprene Type
- AMS 4185, Aluminum Alloy Brazing Wire, 12Si (718)
- AMS 4375A, Magnesium Alloy Sheet and Plate, AX31x, Annealed.
- AMS 4530B, Copper, Beryllium Alloy Sheet and Strip, 98Cu-1.9Be, Solution Treated
- AMS 4532A, Copper, Beryllium Alloy Sheet and Strip, 98Cu-1.9Be, Solution Treated, Half Hard Temper
- AMS 4610E Brass, Free Cutting, 61.5Cu-35.5Zn-3Pb, Half Hard
- AMS 4612C, Brass, Naval, 60.5Cu-0.8Sn-38.7Zn, Hard
- AMS 4625D, Phosphor Bronze, 95Cu-5Sn, Hard Temper
- AMS 4630D, Aluminum Bronze, 90Cu-8.5Al, Soft
- AMS 4650D, Copper, Beryllium Alloy, 98Cu-1.9Be, Solution Treated
- AMS 4720B, Phosphor Bronze Wire, 95Cu-5Sn, Spring Temper
- AMS 4725A, Copper, Beryllium Alloy Wire, 98Cu-1.9Be, Solution Treated
- AMS 4800A, Bearings, Babbitt, 91Sn-4.5Sb-4.5Cu
- AMS 4803A, Zinc Alloy Castings, Die, 4Al-0.04Mg, As Cast
- AMS 4805B, Bearings, Sintered Metal Powder, 89Cu-10Sn, Oil Impregnated
- AMS 4815C, Bearings, Plated Silver, Steel Back
- AMS 4820B, Bearings, Leaded Copper, 71Cu-28Pb-1Ag, Steel Back

Continued on Page 118

Technical Board Approves 67 AMS

Continued

• AMS 4822B, Bearings, Leaded Bronze, 72Cu-25Pb-3Sn, Steel Back
• AMS 4824A, Bearings, Babbitt Coated Bronze, Steel Back
• AMS 4825B, Bearings, Leaded Bronze, 74Cu=16Pb-10Sn, Steel Back
• AMS 4827B, Bearings, Leaded Bronze, 80Cu-10Pb-10Sn, Steel Back
• AMS 4840A, Leaded Bronze Castings, 70Cu-24.5Pb-5.5Sn
• AMS 4842A, Leaded Bronze Castings, 80Cu-10Sn-10Pb
• AMS 4845D, Bronze Castings, 88Cu-10Sn-2Zn
• AMS 4846A, Bronze Castings, 87Cu-11Sn-2Zn
• AMS 4855B, Bronze Castings, 85Cu-5Pb-5Sn-5Zn
• AMS 4860A, Manganese Bronze Castings, 58Cu-39Zn-1.8Fe-1.0Al-0.5Mn
• AMS 4862B, Manganese Bronze Castings, 64Cu-24Zn-5.2Al-3.8Mn-3.0Fe
• AMS 4870B, Aluminum Bronze Castings, Centrifugal and Chill, 85Cu-11.2Al-3.6Fe, As Cast
• AMS 4871B, Aluminum Bronze Castings, Centrifugal and Chill, 85.3Cu-10.9Al-3.6Fe, Heat Treated
• AMS 4872A, Aluminum Bronze Castings, Sand, 85Cu-11.2Al-3.6Fe, As Cast
• AMS 4873A, Aluminum Bronze Castings, Sand, 85.3Cu-10.9Al-3.6Fe, Heat Treated
• AMS 5024C, Steel, Free Cutting (0.32-0.39C) SAE 1137
• AMS 5053A, Steel Tubing, Welded, 0.08-0.13C (SAE 1010) Annealed
• AMS 5310B, Iron Castings, Pearlitic Malleable
• AMS 5351A, Steel Castings, Sand, Corrosion Resistant, 12.5Cr
• AMS 5365A, Steel Castings, Sand, Corrosion and Heat Resistant, 25Cr-20Ni
• AMS 5373A, Alloy Castings, Sand, Corrosion and Heat Resistant, Cobalt Base, 28Cr-5W
• AMS 5389A, Alloy Castings, Sand, Corrosion and Heat Resistant, Nickel Base, 17Mo-15Cr-6Fe-5W
• AMS 5392C, Alloy Iron Castings, Sand, Corrosion Resistant, 15Ni-6Cu-2Cr
• AMS 5542C, Alloy Sheet, Corrosion and Heat Resistant, Nickel Base 15Cr-7Fe-2.5Ti-1(Cb+Ta)-0.7Al
• AMS 5626A, Steel, High Speed, 18W-4Cr-1V
• AMS 5667C, Alloy, Corrosion and Heat Resistant, Nickel Base, 15Cr-7Fe-2.5Ti-1 (Cb+Ta)-0.7Al
• AMS 5668C, Alloy, Corrosion and Heat Resistant, Nickel Base, 15Cr-7Fe-2.5Ti-1 (Cb+Ta)-0.7Al
• AMS 5687A, Alloy Wire, Corrosion and Heat Resistant, Nickel Base, 15.5Cr-8Fe, Annealed
• AMS 5690D, Steel Wire, Corrosion Resistant, 17Cr-12Ni-2.5Mo (SAE 30-316)
• AMS 5770B, Alloy, Corrosion and Heat Resistant, Iron Base, 20Cr-20Ni 20Co-4W-4Mo-4(Cb+Ta), Solution and Precipitation Treated
• AMS 6324A, Steel, 0.7Ni-0.6Cr-0.25Mo (0.38-0.43C)
• AMS 6450B, Steel Spring Wire, 0.95Cr-0.2V (0.48-0.53C) SAE 6150
• AMS 7240A, Washers, Spring Lock
• AMS 7247A, Inserts, Thread Form, Phosphor Bronze, 95Cu-5Sn
• AMS 7301B, Steel Springs, Highly Stressed, 0.95Cr-0.2V (0.48-0.53C) SAE 6150
• AMS 7304A, Steel Springs, 0.85-1.05C
• AMS 7310B, Piston Rings, Cast Iron
• AMS 7311A, Piston Rings, Centrifugally Cast Iron, 0.5Mo-0.5Cu
• AMS 7320A, Sealing Rings, Cast Leaded Bronze, 79Cu-16Sn-5Pb
• AMS 7322A, Sealing Rings, Cast Bronze, 80Cu-19Sn
• AMS 7452B, Bolts and Screws, Steel, Alloy, Heat Treated-Roll Threaded
• AMS 7456B, Studs, Steel, Alloy, Heat Treated-Roll Threaded
• AMS 7493, Rings, Flash Welded, Non-Austenitic Corrosion Resistant Steels
• AMS 7496, Rings, Flash Welded, Carbon and Loy Alloy Steels.

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1951 and May 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

John Evan Fears, Jr. (A), William F. Sadler (A), Tom Turney (M).

Baltimore Section

Joel M. Jacobson (M), John G. Worman (M).

British Columbia Section

William E. Atkinson (M), Joseph Scott Otis (A), William Fowler Otis (A).

Buffalo Section

John A. Mattison (M).

Canadian Section

T. J. Bell (A), William Hannah (A), Harford Hughes (J), Lt. Col. Peter C. King (M), Charles William Tunis (A), Richard B. Vesey (A), Lloyd Brian Walker (M).

Chicago Section

John B. Baker (M), Willis M. Bercaw (A), Kenneth Bruce Bruckelmeyer (A), Charles F. Bunker (M), Sinclair Fielder Cullen (J), Arthur C. Davis (M), L. W. Ehlers (A), Frederick H. Engelke (M), Clarence O. Goff (A), John G. Hallin (J), Ralph L. Handy (M), Harry B. Holthouse, Jr. (M), Sherman M. Katz (M), C. Hyatt King (A), P. H. Korrell (M), Lewis C. Laderer (A), Milton M. Marisic (M), George E. Mittelman (A), Charles J. Parker (M), Doyle Reynolds (A), Clinton G. Rood, Jr. (J), Robert W. Trueblood (A), John Joachim Unger (J), Joe Valence (M), Peter Wargo (M).

Cincinnati Section

Robert B. Bing (A), William R. Dally (A), Allen W. Goode (A), Kenneth M. Lamb (A).

Cleveland Section

John Balint (A), Roger Glen Benjamin (J), Carl M. Bliss (M), Gaines M. Cook, Jr., (J), Holger Ridder (A), Theodore A. St. Clair (M), Robert John Taylor (J), William Thorrat (J), Peter Usalis (M), Joseph E. Zuber (M).

Colorado Group

John N. Gromer (M), T. Allen Pelsue (A).

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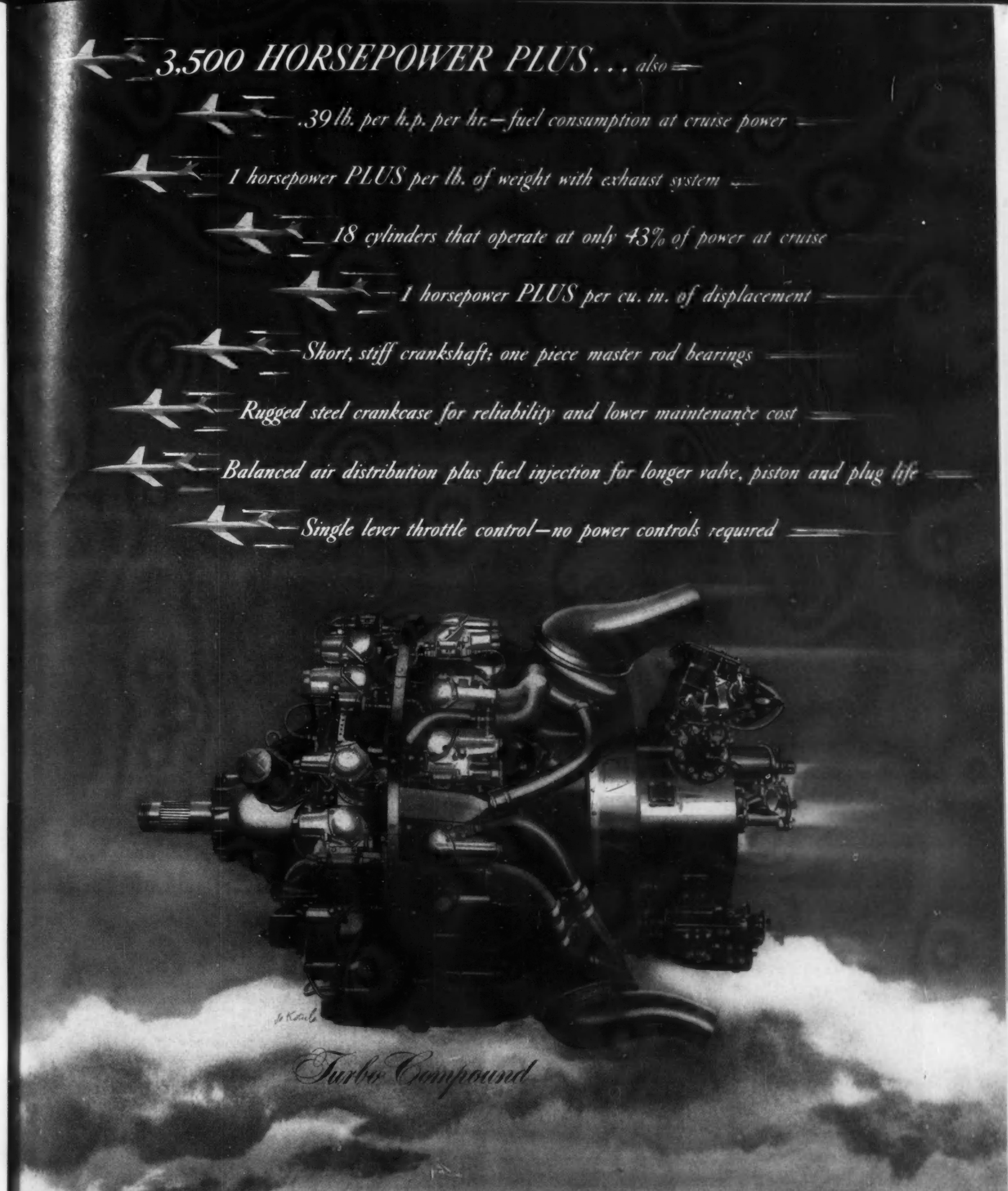

3,500 HORSEPOWER PLUS . . . also
.39 lb. per h.p. per hr.—fuel consumption at cruise power
1 horsepower PLUS per lb. of weight with exhaust system
18 cylinders that operate at only 43% of power at cruise
1 horsepower PLUS per cu. in. of displacement
Short, stiff crankshaft; one piece master rod bearings
Rugged steel crankcase for reliability and lower maintenance cost
Balanced air distribution plus fuel injection for longer valve, piston and plug life
Single lever throttle control—no power controls required
Turbo Compound
WRIGHT
The World's Finest Aircraft Engines
AERONAUTICAL CORPORATION
WOOD-RIDGE, N. J. • A DIVISION OF
CURTISS-WRIGHT

New Members Qualified

Continued

Dayton Section

Gerald E. Keinath (J), Hugh Alexander Williams, Jr. (J).

Detroit Section

Charles C. Adams (J), John J. Armstrong (J), Charles L. Burleigh (A), Edwin A. Desmond, Jr. (M), Gideon A. DuRocher (M), Henry H. Durr (M), Joseph H. Fox (J), John T. Hadwin, Jr. (M), Drew C. Haneline (A), Thomas L. Heller (J), John T. Hoban (M), John G. Hodnicsak (J), John Stephen Holton (A), Richard D. Jacobs, II (M), Harold William Johnson (M), Charles J. Koehn (A), Alexander J. Lapointe (M), Howard E. Lukey (A), James W. MacQueen (M), J. F. Masden (J), Belding Henry McCurdy (M), Malcolm R. McKellar (M), John F. McLean, Jr. (M), N. P. Miller (M), Robert J. Offer (M), Rowland George Oonk (J), Sylvester Patyk (J), Donald Pickles (M), Edward K. Pilcher (A), Robert F. Ploeger (J), David Turner Roberts (J), L. S. Sanford (M), John Gallus Schaub, Jr. (J), Arthur J. Schuneman (J), Robert A. Stranaham, Jr. (A), Karl Melton Unser (J), Everett C. Vallin (M), Arthur M. Waldo (M), Richard W. Wantin (M), Howard H. Wilder (M).

Indiana Section

Laurence E. Bowen (M), Leo M. Darts (A), Keith D. Evans (M), Carl J. Hassett (A), Forrest E. Hull (M), Carl A. Lindblom (M), Melvin Joseph Slater (M), C. Stanley Sundling (M).

Metropolitan Section

Felix W. Braendel (M), Fred H. Bromm (M), Samuel R. Chasalow (A), John M. Ciborski (M), Edward J. Crowley (J), Harald Finnstrand (M), John R. Flanagan (M), Herbert S. Fried (J), John A. Jones, Jr. (M), John B. Moore (M), William J. Seigel (M), Raymond C. Silvers (M).

Mid-Continent Section

Warren A. Brown (J), R. C. Neely (A), Robert W. Unterreiner (J), Robert E. Weintraut (J).

Milwaukee Section

E. C. Brekelbaum (M), Leo T. Brinson (M), Rupert J. Loeffler, Jr. (J), Lester M. Maresh (J).

Montreal Section

John S. Brock (M), Richard Henry Hales (J).

New Members Qualified
Continued

New England Section

Alfred F. Anderson, Jr. (M), John H. Durant (A), Walter J. Good (A), Hans Lanz (M), Percy Stanwood Ross (A).

Northern California Section

Alfred G. Anderson (J), Lester E. Lewis (A).

Northwest Section

David A. Tozer (A).

Oregon Section

Raymond H. Wolfgram (A).

Philadelphia Section

John K. Montgomery (M), Charles W. Rak (J), George H. S. Snyder (M), Robert Allen Winemiller (A).

Pittsburgh Section

E. Newman Giles (A), Maynard W. Teague (M).

San Diego Section

Harry F. Bartling (M).

Southern California Section

Mark J. Biondich (A), Marvin N. Birken (J), Jack M. Craig (A), Edward R. Daley (A), D. L. Francisco (A), George S. Gregson (J), Strother C. MacMinn (A), A. F. Reznicek (M), Lt. W. R. Rogers (J), Samuel J. Smyth (J), Morgan L. Sweeney, Jr. (M), Joseph D. Thompson (A), Curtis R. Washburn (M).

Southern New England Section

Richard C. Keane (M), Stanley M. Terry (M).

Spokane Intermountain Section

Harold A. Halstead (A).

Syracuse Section

Edward R. Brewer (M), William C. Coburn (M), Glenn H. Dingman (M), Charles W. Trout (A), Harold R. Turner (M).

Texas Section

C. A. R. Anderson (A), Edward J. Bowhay (M), Robert R. Jameson (J), James Burr Powell (A), Tom P. Steger, Jr. (A), William Ruskin Wood (J).

Twin City Section

Lawrence G. Boschma (J).

Continued on Page 124

New Members Qualified

Continued

Virginia Section

Beverley R. Belcher (A), W. I. Shipp (A).

Washington Section

Clarence William Lindgren (A).

Western Michigan Section

William M. Frank (A).

Wichita Section

John R. Thomas (M).

Outside Section Territory

Paul C. Brumback (A), Paul S. Dean (M), Archie D. Dennis (A), Daniel Fort Flowers (M), Burr C. Folts (M), Merlin Hansen (M), Robert B. Humphreys (M), Howard Jensen (SM), Lemuel R. Ladd (SM), Robert S. Martin (J), 1st Lt. William Stephen Matthews, Jr. (J), Francis Thomas McQuire (M), Eldon Miller (A), Merle L. Miller (J), E. W. Rauh (A), James R. Tucker (A).

Foreign

Roy Hewitt Davies (J), England; Orazio Satta Puliga (FM), Italy.

Applications Received

The applications for membership received between April 10, 1951 and May 10, 1951 are listed below.

Atlanta Group

Herman G. Heller.

British Columbia Section

John William Podmore.

Buffalo Section

Glenn A. Johnson, Fred A. Stenning, Donald Stoltman, Eugene Willihnganz.

Canadian Section

Reny Barki.

Chicago Section

Lyle C. Atwood, George A. Bobelis, Frank Bott, Edward Brenner, Boris B. Brouevitch, Norman B. Howells, Robert F. Jaske, John F. Kreiner, Elwood W. Krueger, Frederic G. Lussky, Robert L. May, Charles H. Morse, Jr., Harold L. Sanders, Raymond W. Schulte, Ed-

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Applications Received

Continued

ward C. Shaar, Harold R. Taliaferro, Chester R. Wiedemann, William R. Williams.

Cincinnati Section

Carl F. Bennett, Milton Gervin, Walter H. Kruse, Jr.

Cleveland Section

John E. Carnahan, Cecil H. Hubbard, Thomas E. Kartisek, Gale T. Warner.

Detroit Section

Harold A. Beatty, George Brenz, William J. Clark, Capt. Robert H. Freeburger, Owen William Hale, William Harms, Charles Gordon Hicks, Alvin M. Kurz, R. G. Hogan, E. D. Marande, George N. Medawar, John C. Miller, Frederick John Peterson, James M. Prange, Stefan Pronaszko, C. W. Rainey, Robert S. Rarey, Harvey Hershel Resnick, G. Scott Sample, Donald D. Simpson, David M. Skirving, Witold K. Skuba, Chris L. Sloman, Rufus Charles Snook, Alfred L. Stem, John O. Stephenson, Edward West.

Hawaii Section

William R. Chillingworth, Richard G. Deemer, Albert Ruddle, Jr., Gary D. Sakata.

Indiana Section

Robert M. Tuck.

Kansas City Section

Kenneth Flint Long, Claude A. McComb, Ralph V. Shuff.

Metropolitan Section

James G. Campbell, William N. Fenney, Jr., Michel J. Fliegler, Harry Gelbach, John Goldhammer, Herbert C. Morris, Thomas John O'Grady, Jr., Bennett H. Ravlin, Alfred K. Wright, Daniel Yawnick.

Mid-Continent Section

Glenn E. Holman, Robert J. Masar.

Mid-Michigan Section

L. V. Rangeler.

Milwaukee Section

Robert Walter Hanak, Joseph Morvak, Richard E. Rogers, Giles Emery Smith.

Mohawk-Hudson Group

William C. Fuhlborn.

Montreal Section

Joseph A. De Grace, Albert Victor Delcloo, John H. Glashan, William G. Green, Guy Kenneth Mantha.

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Applications Received

Continued

New England Section

Harold A. Connor, P. M. Ku.

Northern California Section

Robert M. Snyder, Richard S. Taylor

Oregon Section

Ancel S. Page.

Philadelphia Section

Harry L. Cuthbert, George C. Flynn, Kent Hyatt, Robert Charles Lederer, Donald K. Marsh, Edward H. Smith, Edward L. Spicer, Lawrence E. Vogt.

St. Louis Section

Harold Kramer, Thomas L. Walker, Jr.

San Diego Section

Murray Ogman.

Southern California Section

Joseph Michael Collins, Ralph D. Hall, Eugene Alvin Ransom, Albert H. Ross.

Southern New England Section

Erwin F. Grimmeisen, C. E. Holtsinger, Jr., J. Frederic Johnson, Herbert M. Nicholas.

Syracuse Section

Stephen Edward Gregoire.

Texas Section

Nolan J. Clark, I. G. Kennon, Jr., V. W. Watkins.

Twin City Section

Robert F. Piculell.

Virginia Section

Marcus A. Fuller, Jr., Eugene B. Sidoli, Jr.

Washington Section

Ray P. Teele.

Western Michigan Section

William Keller McInerney, William J. Purchas, Jr., C. W. Truxell, Jr.

Outside of Section Territory

Howard C. Aldridge, Edward Thompson Curlette, Charles Henry Dawson, Colin D. MacKenzie, Geoffrey G. Morgan, Harold O. Skinner, J. H. Walters.

Foreign

Giuseppe Alfieri, Italy; Keneth Barlow, England; Harold George Dunn, England; John Edward Hanbury, England; Debi Prasad Mukherji, India; Harry Viktorsson, Sweden; Raymond P. Vincent, Scotland; Eric Wilcock, England; Mario Zavattaro, Italy.

For the Sake of Argument

In the Other Fellow's Place . . . .

By Norman G. Shidle

To figure why others act the way they do, it is often recommended:

"Put yourself in the other fellow's place . . . . How would you feel? . . . . How would you act?"

When we try this method of understanding, how often do we come up with the answer:

"Well, I certainly wouldn't feel or act the way *he* does!"

The attempt leads to solidification of our existing opinions about the other fellow more often than to understanding better what makes him do and say what he does. To know that, we have to get our own ego out of the way—and putting our *self* in his place does no such thing.

Gerald Heard quotes Morley, the great liberal historian as saying: "You must never denounce, you must explain, otherwise you are just at the level of the person you abuse." Then, adds: "But I think we can go further. We must not only explain, we must re-interpret."

Figuring what *I* would do under the circumstances faced by another has little relation to understanding why *he* acts as *he* does. The real problem is to see the situation through *his* eyes . . . . not through our own eyes transplanted into his situation.

A great novelist is one who can feel how differently each of his characters would react to a given circumstance . . . . whose people think and reason and act on motivations sparked by different emotional backgrounds, different religious convictions, different educations—different ethical standards. (John Galsworthy did just this in his famous "Forsyte Saga.")

A great propagandist—who uses the novel form as a vehicle to carry his message—creates more puppets than characters. He merely puts himself in the other fellow's place; makes his people act the way *he* would, if faced with their situations. (H. G. Wells did this in "Tono Bungay" —and practically all of his other novels.)

The great novelist understands other people; the great propagandist wants them to be what he can understand.